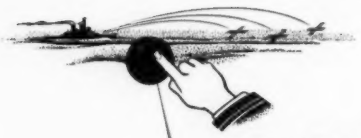
CHNOLOGY DEPT.

TECHNOLOGY REVIEW

June 1954

V56 #8

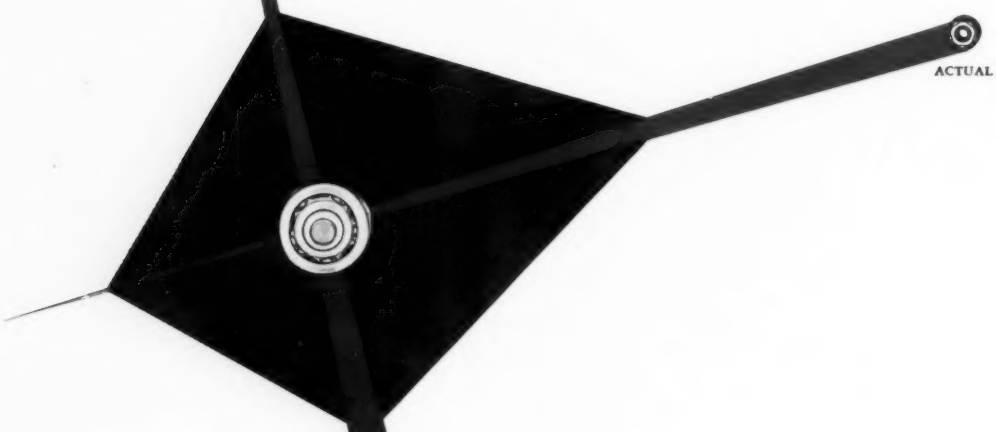
PUBLIC LIBRARY
JUN 1 1954
DETROIT



HERE'S **HOW** KETAY FIRE CONTROL RELAYS

keep naval guns "ON TARGET"

. . . with MPB bearings



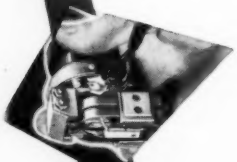
ACTUAL SIZE MPB 3C

ac rate concentricity

of miniature bearing roller guides

increases relay sensitivity

and dependability



ntrol relay designed and manufactured by Ketay Manufacturing Corporation of rk.

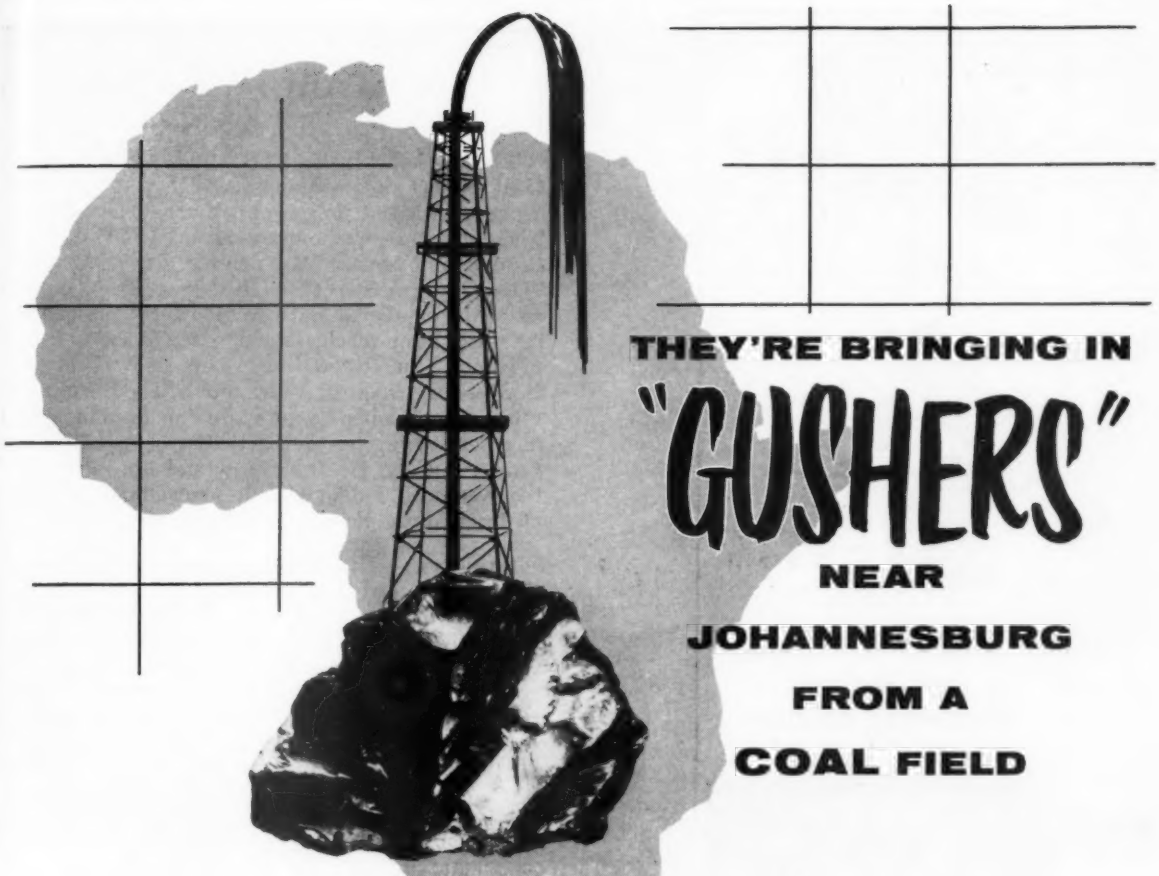
OPERATING CONDITIONS — maximum sensitivity and consistency of response depend on free rolling, concentrically accurate bearings . . . bearings serve as rollers and guides for rotating armature shaft which is displaced right and left to close desired circuits . . . unit actuated by 3 to 40 volts. CRITICAL — low-friction bearing rotation . . . ability to withstand 2,000 ft.-lbs. shock (equal to recoil of 16 in. naval guns), plus temperature changes from −55° C to +71° C . . . long wear and attention-free bearing operation. RESOLVED — by use of MPB No. 3C, radial retainer bearing.

In any problem involving miniaturization of precision mechanisms, when accuracy and dependability are essential, it pays to specify MPB miniature ball bearings. Each MPB bearing is the product of exclusive production processes, designed to hold ultra-precise tolerances . . . give long, trouble-free operation.

For design ideas, get the most complete information ever offered on miniature bearings. Request, on your letterhead, MPB catalog —54d.

see our catalog in PRODUCT DESIGN FILE or write for copy

Miniature *Precision* Bearings, Inc. MPB Keene, New Hampshire



THEY'RE BRINGING IN "GUSHERS" NEAR JOHANNESBURG FROM A COAL FIELD

South Africa—land of gold and diamonds and uranium . . . of copper, tin and coal—is one of the world's greatest storehouses of mineral wealth.

But nature neglected to provide a twentieth-century reservoir of petroleum in this remote, oil-hungry land. And, since South Africa boasts more automobiles per capita than any country other than the United States, the need for refined petroleum products is large and constant.

South Africa's first vigorous answer to the petroleum shortage will be in operation in a few months. It is the first oil-from-coal plant in Africa, and one of the largest ever built. Located fifty miles south of Johannesburg, this refinery—a project of South African Coal, Oil and Gas Corp., Ltd. (SASOL)—will convert 3,000 tons of coal daily into usable petroleum products.

The size of the SASOL project may be gauged by the size of its boilers. Furnished by Combustion Engineering, Inc., they are the largest ever erected on the African continent, and include all that's latest and best in boiler design. The four C-E Boilers—which supply all the steam needed for power, process and heat in this new plant—have a continuous generating capacity of nearly a million and a half pounds of steam per hour.

Long recognized in America for their outstanding reliability and economy, C-E Steam Generating Units in recent years have been selected for many of the most modern power installations throughout the free world.

So, whatever your steam needs, from small industrial boilers up to the world's largest . . . for heat, power or process . . . for stationary or marine use—there's a C-E Boiler that will meet your requirements exactly.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

C-E

B-727

BOILERS, FUEL BURNING & RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS & FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

THE TECHNOLOGY REVIEW, June, 1954, Newsstand Edition. Vol. LVI, No. 8. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription, $4.00. Entered as second-class matter December 23, 1949, at the Post Office at Bristol, Conn., under the Act of March 3, 1879.

The Most Complete and Modern Die-Casting Facilities in New England

Our latest type high pressure Lester Phoenix machines insure precision low-cost castings.

You can depend upon our proven know-how to design and develop your most intricate castings.

Ask to have the Mason representative call, or send us your prints. Our Engineering department will give every request, whether large or small, conscientious prompt attention.

L. E. Mason is an approved source for America's leading manufacturers.

L. E. MASON CO.
BOSTON 36, MASS.
Established 1931

THE TABULAR VIEW

Tired. — What makes us tired? Why do we sleep? Could we get along without sleep? If so, for how long a period, without deleterious results to our health? These are some of the questions for which a search is made by FREDERIC W. NORDSIEK, '31, in his article "Tired Nature's Sweet Restorer" (page 393). But for all of the emotional and psychic effects of sleeplessness, the basic mechanism of sleep remains a vast unknown. An editorial associate since 1944, Mr. Nordsiek is a frequent contributor to The Review and other journals when he can spare time from his duties in administering research activities of the American Cancer Society. He is a fellow and life member of the American Public Health Association, and past chairman of the Food and Nutrition section.

Inventors. — The future of discovery and invention in the broad field of technology is examined in this issue by J. L. B. BLIZARD, '49, whose article appears on page 395. After receiving the A.B. degree with high honors from the University of Rochester, and the Ph.D. degree from M.I.T., in 1945 and 1949, respectively, Dr. Blizard became lecturer and assistant professor of physics at Hofstra College, and for the past year has been lecturer at the University of Connecticut. Dr. Blizard is now studying the development of science and technology and scientific man power at Columbia University. It is held that overemphasis on applied research at the present time, at the expense of research in basic science, is a practice well worth serious attention.

Fish. — Following up his article on the dairy industry in the November, 1953, issue of The Review, MILTON E. PARKER, '23, devotes attention in this issue (page 401) to the sea-food industry. Professor Parker is concerned that the rate of population growth exceeds that of our food industry – at least so far as concerns protein production. He looks to the sea to provide ample bounty to our supermarkets and our pharmaceutical and nutrition industries. Professor Parker has been engaged in a wide range of activities in the food industry, becoming manager of production of the Beatrice Foods Company in 1936, and more recently, food-consulting engineer. Since 1948 he has been head of the Department of Food Engineering at the Illinois Institute of Technology.

For the Future. — PAUL COHEN, '35, former editor of *The Tech* and editorial associate of The Review since 1938, provides readers with a brief review of the growth of research activities in the United States during the past decade (page 405). Calling organized research "the generative organ of the industrial state," Mr. Cohen emphasizes that the three and three-quarter billion dollars spent for research during 1952 is truly an investment in the future. Since his graduation from the Institute's Course in Mechanical Engineering, Mr. Cohen has been a research engineer by vocation and a skillful writer and interpreter of science and engineering by avocation.

BEYOND THE HORIZON....

Designers are seeking new alloys from the metallurgist in order to develop higher speed transportation.

Higher speed calls for materials having greater strength in lighter sections, often with little or no sacrifice in toughness. Molybdenum contributes vital properties to better alloys which will certainly be developed for the future.

Climax furnishes authoritative engineering data on Molybdenum applications.

MOLY

Climax Molybdenum Company
500 Fifth Avenue · New York City 36 · N.Y.

PRECISION IS OUR CUSTOM . . .

Diefendorf makes gears only to blueprint and specifications — to the closest tolerances for most precise requirements. A complete organization devoted exclusively to custom work.

All materials, all types. All sizes. Engineering assistance available.

DIEFENDORF GEAR CORPORATION
Syracuse, New York

DIEFENDORF GEARS

THE ORIGINAL SWING BOOM MOBILE CRANE WITH FRONT-WHEEL DRIVE AND REAR-WHEEL STEER

KRANE KAR

MOVES LOADS EASIER - FASTER - SLASHES COST OF MATERIALS HANDLING

***KRANE KAR** handles loads at Sides as well as at Front.*

Gas or Diesel. Pneumatic or solid rubber tires; 9 to 37 ft. booms or adjustable telescopic booms; electric magnet, clamshell bucket, and other accessories available.

At your service *24 hours every day* because it is gasoline-powered (no layups for battery charging). Works inside and outside your plant. ***KRANE KAR*** serves also as an auxiliary to existing crane facilities . . . and as an emergency tool for plant maintenance. *Let us show you.* Ask for Bulletin No. 79 or for a Sales-Engineer.

1½, 2½, 5 and 10 ton capacities.

SILENT HOIST & CRANE CO.
891 63rd ST., BROOKLYN 20, N. Y.
Eric Martin Wunsch, II, '44 Jim Beach, II, '50

MAIL RETURNS

Eloquence of Sculpture

FROM WELLES BOSWORTH, '89:

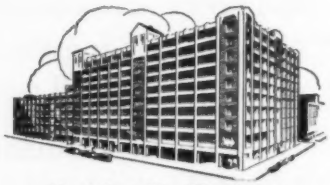
Your article about the history of the architecture of M.I.T. in the April Review has of course interested me* probably more than any other of your readers . . .

I must tell you about the Rogers Building and the statues, which those four pedestals are so patiently waiting for. I have a high regard for the eloquence of sculpture in connection with architecture. I showed on my first project for the M.I.T. group a great heroic-size statue, representing the spirit of knowledge, on the axis of the Main Court. I have shown it on every drawing and painted it on airplane photos since the beginning, and I hope keenly to see it realized, for it would be so fine there as a keynote to the whole institution, like the statue of Athene was on the Acropolis, or the Alma Mater at Columbia in New York. . . . But so far, committees always think the easiest way to cut down cost in building is leave off sculpture.

I well remember Dr. Compton's writing me asking me to describe to him how I visualized the new Rogers entrance and vestibule to M.I.T. from Massachusetts Avenue, and my telling him there ought to be four statues of the great Greek founders of modern learning in it. He and I later agreed on them as Aristotle for the Sciences, Archimedes for Engineering, Ictinus (and Callicrates looking over his shoulder at a plan of the Parthenon) for Architecture. Seeing these statues would certainly inspire every student and teacher of M.I.T. to follow their example and hope to become "great." The pier of masonry back of each statue was to bear incised outlines illustrating their inventions, like the water screw of Archimedes and the Parthenon of Ictinus, or famous words of theirs. The cost of this sculpture was relatively small, as the statues could well be made of artificial stone cut from plaster models. What fine memorials these would make, for distinguished M.I.T. graduates. The idea must be continually kept alive, and I hope you may find a way of bringing it somehow into print where the Alumni will see it.

Vaucresson, Seine et Oise, France

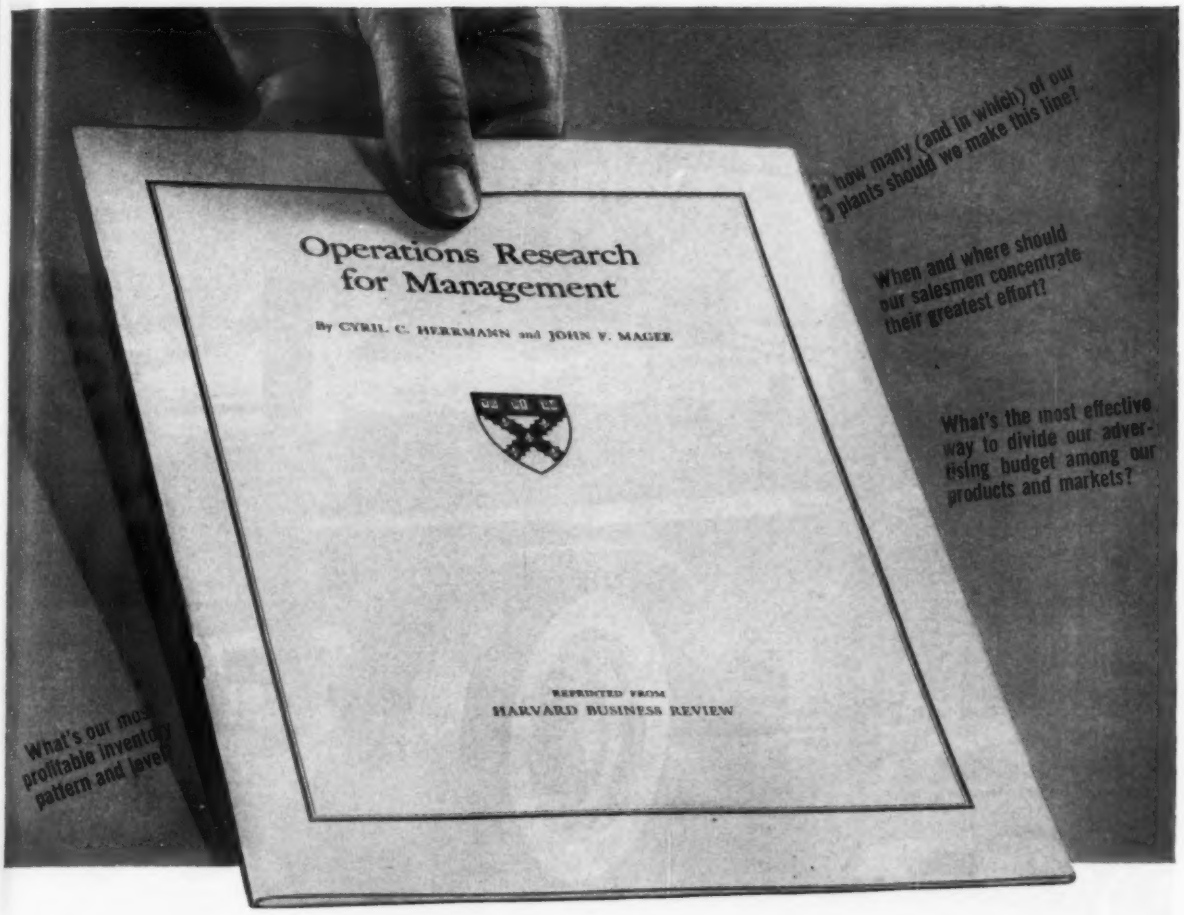
* [Mr. Bosworth is the architect of the main group of M.I.T. Buildings erected in Cambridge in 1916.—Ed.]



Macy's Long Island Warehouses
Robert D. Kohn, Architect
14 Contracts

For 37 years we have specialized in building industrial plants — a guarantee of "know how" in industrial construction.

W. J. BARNEY CORPORATION
Founded 1917
101 Park Avenue, New York
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, President


Operations Research
for Management
By CYRIL C. HERRMANN and JOHN F. MAGEE
REPRINTED FROM
HARVARD BUSINESS REVIEW
In how many (and in which) of our 3 plants should we make this line?
When and where should our salesmen concentrate their greatest effort?
What's the most effective way to divide our advertising budget among our products and markets?

New Concept Simplifies Business Decisions

Management now has a new way to attack business problems . . . operations research. Here are a few diverse problems it has helped to solve:

- Directing salesmen to the right accounts at the right time.
- Fitting incentive payment plans to management objectives.
- Controlling levels of purchase, production, inventory, shipment and customer service to maximize total profits.
- Dividing the advertising budget among products and markets in the most profitable way.
- Balancing quality standards and cost standards in procurement and in successive production operations to find lowest over-all costs.
- Finding and evaluating the basic purposes, elements, and costs of large clerical operations and specifying design requirements — from pen and ledger to electronic information-handling devices.

How It Works . . . Operations research makes possible these accomplishments and many others because (1) it helps single out the critical issues which require executive appraisal and analysis, and (2) it provides quantitative analyses to support and guide executive judgment. It eases the burden of effort and time on executives but increases the potential of their decision-making role. Thus operations research contributes toward better management.

A Few Case Histories . . . How does it work? How does it differ from other services to management? What are its limitations and potentials? These questions are answered in a booklet called "Operations Research for Management". You can have it by return mail. With it we'll send "A Few Case Histories", based on the experience of our pioneer operations research group working with American management since 1949. These booklets will help you to decide whether operations research can lighten your decision-making burden. Phone Boston, UNiversity 4-9370, or write:

Arthur D. Little, Inc.

Research • Consulting • Engineering

36 Memorial Drive, Cambridge 42, Massachusetts

Sheer Luxury...and worth every cent of it!

New All-Nylon Cord Double Eagle

with the new quiet

"Velvet Ride"!

Though no expense was spared in its manufacture, the new All-Nylon Cord Double Eagle by Goodyear is the best investment you can make in a passenger car tire.

Ingenious new "Safety Silencers" in the tread practically eliminate "squeal" on turns to give you a new, smooth, "velvet ride."

And you get greater traction from its exclusive diamond pattern Resist-a-Skid Tread. Greater mileage from its tougher, wear-resistant tread. Greater protection from impact blowouts, too, for the All-Nylon Cord Double Eagle is actually up to 1½ to 2 times stronger than standard cord tires.

And remember, *only* Goodyear gives you Triple-Tempered 3-T Nylon Cord. Goodyear, Akron 16, Ohio.

GOODYEAR

The world's finest tire...by miles!

Double Eagle, T.M.—The Goodyear Tire & Rubber Company, Akron, Ohio

Cambridge Common (May Contents page) contains the ancient cannon which was used to bombard General Gage's Army in Boston during the siege of 1775; it also contains the monument, with statue of Lincoln, as a memorial to those who died in service during the Civil War.

Raymond E. Hanson

How Well Do You Know Boston?

Believe it or not, this quiet, idyllic spot is near one of the busiest and most active business corners of Boston. The point at which the exposure was made makes the difference. Can you identify this stone building and tell where it is located? If not, see the Contents page of the July issue.

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CONTENTS *for June, 1954*

Vol. 56, No. 8

Editor:
B. DUDLEY

Business Manager:
R. T. JOPE

Circulation Manager:
D. P. SEVERANCE

Editorial Associates:
PAUL COHEN
J. R. KILLIAN, JR.
F. W. NORDSIEK
J. J. ROWLANDS

Editorial Staff:
RUTH KING
EVANGELINE SFERES

Business Staff:
EILEEN E. KLIMOWICZ
MADELINE R. MCCORMICK

Publisher:
H. E. LOBDELL

GRAIN ELEVATORS, DULUTH, MINN. • *Photograph by H. Armstrong Roberts* ..... THE COVER

ALBATROSS • *Photograph by C. E. Patch* ..... FRONTISPIECE 388

TIRED NATURE'S SWEET RESTORER ..... BY FREDERIC W. NORDSIEK 393
Although the emotional and psychic effects of sleeplessness are profound, the basic mechanism of sleep remains almost as much of a mystery as ever

THE FUTURE OF DISCOVERY AND INVENTION .. BY J. L. B. BLIZARD 395
With "group effort" replacing "rugged individualism" and our emphasis on applied, rather than basic, science, what is the prospect for future discovery and invention?

DOWN TO THE SEA IN SHIPS—FOR PROTEIN .. BY MILTON E. PARKER 401
The sea food industry may be our last big chance to demonstrate that the hypothesis of Malthus has not caught up with us—yet!

INVESTING IN THE FUTURE ..... BY PAUL COHEN 405
A brief review of the growth of research activities in the United States during the past decade

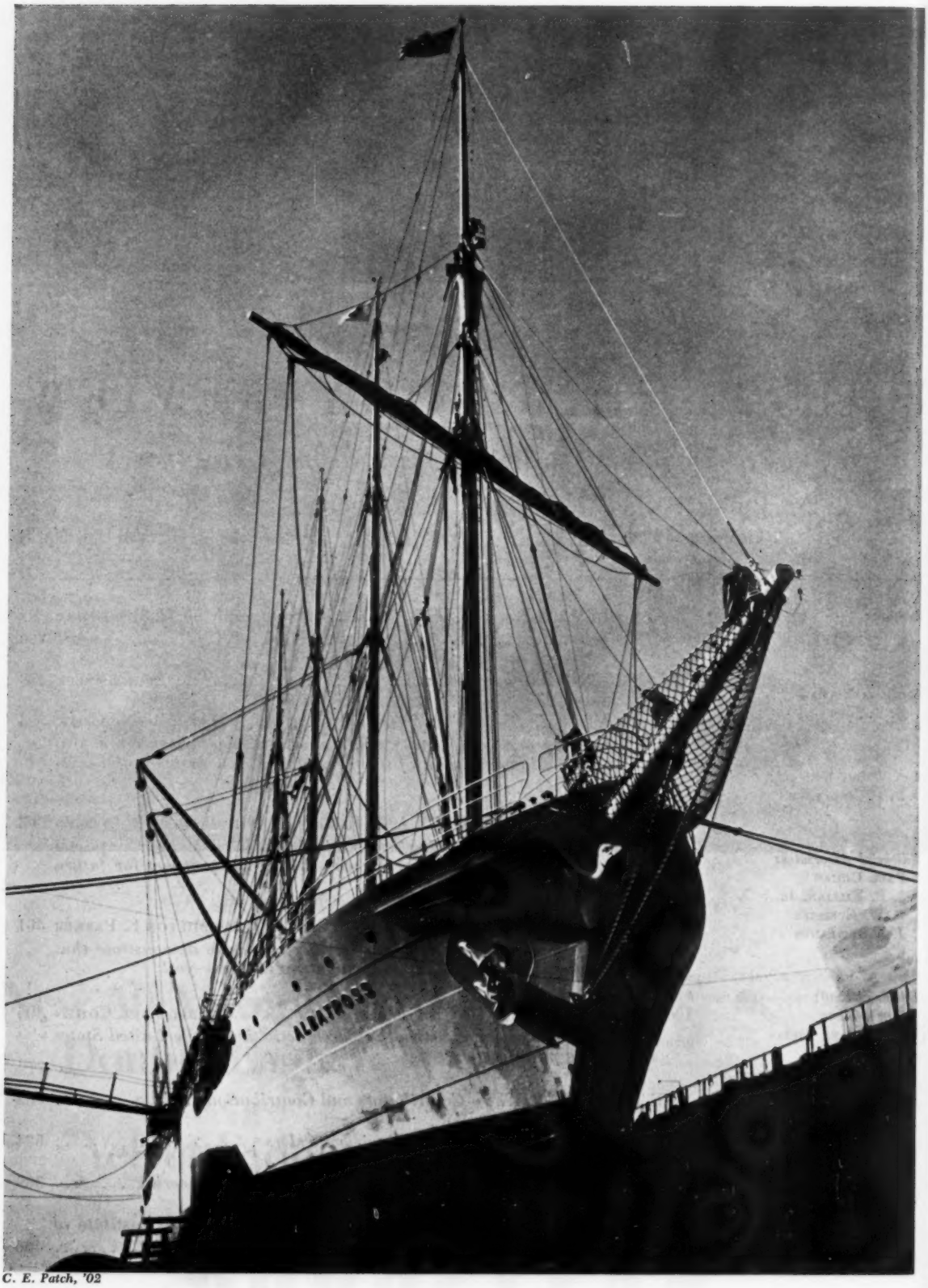
THE TABULAR VIEW • *Contributors and Contributions* 382

MAIL RETURNS • *Letters from Review Readers* 384

THE TREND OF AFFAIRS • *News of Science and Engineering* 389

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 406

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Horatio L. Bond, President; H. E. Lobdell, Executive Vice-president; Dwight C. Arnold, Richard S. Morse, Vice-presidents. Donald P. Severance, Secretary-Treasurer. Published at Hildreth Press, Inc., Bristol, Conn. Editorial Office, Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the Post Office at Bristol, Conn. Copyrighted, 1954, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect change of address, for which both old and new addresses should be given.



C. E. Patch, '02

Albatross

American merchant sailing vessels, once proudly sweeping the seas for whale oil, may play an important role in feeding the nation's rapidly expanding population.

THE
TECHNOLOGY
REVIEW

Vol. 56, No. 8 June, 1954

The Trend of Affairs

How High the Sky

A RASH of reports is marking the end of a phase in upper-atmosphere research. With the exhaustion of the supply of *V-2* rockets captured from the Germans at the end of World War II, the sounding of high altitudes with heavy loads of scientific equipment must, for the time being, be conducted with smaller, less expensive rockets and, probably, at a somewhat slower pace.

For decades, scientists have wondered about the nature of the atmosphere above the highest mountains and beyond the reach of airplanes and balloons. Extending no one knows how far into space — perhaps for many thousands of miles — this region of the earth could be probed only by radio beams or by men's minds working from whatever measurements could be made at or near the earth's surface. Incidentally, auroral displays have been measured by triangulation up to heights of 700 miles.

Goddard, in 1919, had proposed that rockets would be ideal vehicles to carry instruments into the upper atmosphere. There, substantially, the idea rested until, during World War II, the Germans developed the huge *V-2*, a 46-foot, multi-ton rocket with a horizontal range in the order of 180 miles. With the collapse of Germany, the rockets not yet expended fell into the hands of the Allies. The share of the United States amounted to about 100 complete rockets and much auxiliary and spare equipment. Literally trainloads of equipment were transported to the White Sands Proving Grounds. Since it was necessary in any case to expend these rockets in order that the military become more familiar with the techniques of designing and handling liquid fuel rockets, it was decided that the war heads might just as well be loaded with scientific apparatus as with dead weight. The invitation in 1946 by the Ordnance Department to various scientific groups to make use of these facilities resulted in the V-2 Upper Atmosphere Panel.

The first *V-2* launched in this country rose from its mount on April 16, 1946, carried a single Geiger counter and, as far as rocket performance was concerned, was a failure. Sixty-six *V-2's* had been launched from White Sands and three elsewhere by October 29, 1951. Two thirds of these vehicles reached altitudes exceeding 50 miles. One two-stage rocket consisting of a *V-2* and a *WAC Corporal* reached the record height of 250 miles. All told, they carried a total of over 20 tons of instruments farther into the sky than scientists had ever penetrated.

The rocket is far from an ideal carrier of equipment. It does not yet go high enough. It stays at, or near, extreme altitude for only a few minutes. And it subjects its load to some dizzying changes in environment, to sharp temperature and pressure variations, high acceleration, heavy vibration, and to a savagely severe impact on returning to earth.

One of the more important fields of exploration aided by rocket firings have been studies of the sun's radiations, particularly in the far ultraviolet. The earth's atmosphere is such an efficient absorber of these wave lengths that little can be learned from measurements at the earth's surface. Servo-driven, sun-following spectographs are among the special devices developed for this field.

Rocket measurements have revealed that the normal energy received by the earth at an altitude far above the bulk of the atmosphere is about 3 per cent higher than hitherto extrapolated from measurements at lower altitude. Wind velocities and air temperatures have been measured directly at hitherto inaccessible levels, although at levels above 35 miles the atmosphere is so rarefied that temperatures do not have their sea-level significance. It will undoubtedly be years before the full significance of the measurements so far accumulated are absorbed into the body of knowledge about the composition of the earth's atmosphere and of the conditions of flight in near vacuums.

Making the Last Drop Good

COFFEE is one of the most popular beverages in the United States. The per capita consumption is approximately 15 pounds and the total consumption is two and one-half billion pounds. If one pound makes 40 cups of beverage, then the annual per capita consumption is 600 cups. However, this figure assumes that every man, woman, and child (including babies) is a coffee drinker. A more realistic figure can be obtained by assuming that the average coffee drinker consumes about two cups per day, or about 750 cups per year. Coffee has gained its eminent position in the household because it tastes good; even before it reaches the mouth, its pleasant fragrant aroma foretells of the satisfaction yet to come.

As a result of much painstaking effort and experience, by and large, manufacturers have created the kinds of coffee most acceptable to consumers. In spite of such effort, the final step of extracting a delectable brown liquid from roasted and ground beans is a crucial one. Although it is not difficult to make a good cup of coffee, lack of knowledge, carelessness, and circumstance often act separately or together to prevent the consumer from receiving the full measure of enjoyment the manufacturer has struggled so diligently to achieve.

Circumstance, for example, certainly plays an important role in the success or failure of coffee making. An essential component of coffee beverage is water. Unfortunately the water we drink and use in the preparation of coffee is not simply H_2O as the chemists would have it, but is a complex solution containing many different chemical compounds. The complexity of the solution varies greatly according to region of origin, the type of storage and treatment it receives, and many other factors. Experience has shown that the New England coffee drinker is fortunate in having available waters which, for the most part, are quite suitable for making good coffee.

A vast knowledge concerning types and composition of water supplies throughout the country has become available over the years, but relatively little is known about the effect of water impurities on the flavor of beverage coffee. Realizing this, the Coffee Brewing Institute, an organization recently established under the auspices of the Pan-American Coffee Bureau and the National Coffee Association, is now collaborating in an investigation of this problem in the Department of Food Technology at M.I.T.

Under the supervision of Ernest E. Lockhart, '34, Associate Professor of Food Chemistry, and his group in the Institute's Food Flavor Laboratories, an extensive study of the chemical composition of waters normal to many typical areas in the United States is in progress. Information derived from this study is being used to ascertain the identity of chemical impurities, to measure (by means of panel techniques) the effective taste thresholds of chemical impurities, and to prepare synthetic waters containing known concentrations of impurities. Eventually, coffee brewed with synthetic waters of known composition will be studied by flavor panel comparison to determine whether any or some of the impurities present can change the flavor of a standardized control beverage.

The results of this research will demonstrate which impurities destroy the flavor of coffee and to what extent such impurities are discernible. It is hoped that this study may also serve as a basis for recommendations for the treatment of water in hotels, restaurants, dining cars, homes, or other places where coffee is prepared, in order to assist in achieving the ultimate objectives of consumer satisfaction, acceptance, and enjoyment.

Animals Versus Man

THE initial emphasis of public health was prevention of the spread, from man to man, of diseases that affect human beings only. Not until later was attention given to control of infections that attack other living things as well as the human being, and are transmissible from animals to man.

These infections, transmissible from animals to man, may be thrown into two broad groups. First are diseases of animals having no utility to human society. Here protection of the human being can focus on destruction of the animal host, or prevention of its contact with mankind. Examples in this category are the insect-borne diseases, such as yellow fever or malaria. The insect host may be destroyed by insecticides, and by elimination of its breeding places. Or contact with the human being can be prevented by screening of buildings, and the use of insect repellents.

The other category of animal diseases transmissible to man are infections of useful domestic animals. Manifestly the solution here cannot be either to destroy the animal host or to prevent its contact with the human being.

A special expert group, charged with consideration of animal diseases transmissible to man, has been organized in the United Nations, under joint auspices of the World Health Organization and the Food and Agriculture Organization. A recent report of this group lists no less than 86 diseases: 29 caused by worm parasites of various types; 20 by bacteria; 20 by viruses; 8 by Protozoa; and the remainder by miscellaneous infectious agents of other sorts. Ten of the 86 infections are deemed to be sufficiently prevalent to warrant intensive study of methods for their control. These major 10 are:

Trichinosis – infection of swine, man, and other animals by a worm parasite that resides as an adult in the intestinal tract, as larvae in body tissues;

Equine virus encephalitis – an infection of the human central nervous system caused by a virus that also attacks horses;

Bilharziasis – infection of blood vessels or skin, by trematode worms;

Hydatidosis – tapeworm infestation;

Leishmaniasis – infection by a protozoan affecting dogs as well as man, and transmitted by flies;

Leptospirosis – a disease causing jaundice in man, produced by a spirochete (similar to the syphilis organism) affecting rats and dogs as well as man;

Psittacosis (*"parrot fever"*) – caused by a virus infecting parakeets and other birds and producing pneumonia in the human being;

Q Fever – an infection caused by Rickettsia, microorganisms intermediate in size between viruses and bacteria;

Rabies – the well-known infection of man, dogs, and other mammals, caused by a virus;

Tularemia – a bacterial infection of rabbits and other rodents, transmissible to man directly or via insects.

Of these 10 major animal diseases transmissible to man, trichinosis was characterized as "a national disgrace" in a recent editorial in the *American Journal of Public Health*[*] which included the astounding statement: "Trichinosis is undoubtedly the only communicable disease which is more prevalent in the United States than in any other country of the world."

Human trichinosis in the United States is mainly a result of feeding hogs raw garbage. Hogs so fed are likely to become infected from pork scraps in the garbage; when their meat is consumed without sufficient cooking, it is apt to cause human trichinosis. The role of garbage feeding is demonstrated by statistics of an 11.5 per cent incidence of trichinosis in garbage-fed hogs on the eastern seaboard, whereas trichinosis occurs in only about 0.6 per cent of corn-fed hogs in the Central States.

A national conference on trichinosis was held at the headquarters of the American Medical Association in December, 1952. Reports made then estimate, on the basis of autopsy findings, that some 25,000,000 people in this country are infected with trichinosis. A national disgrace indeed! Although many of these infections are symptomless or "subclinical," approximately 16,000 clinical cases of human trichinosis are estimated to occur in this country every year.

Pork, even heavily infested with trichinae, may be eaten with impunity so long as it is well cooked; for the temperatures of normal cooking reliably kill the parasite. Therefore, thorough cooking of all pork, before consumption by human beings, could completely eliminate trichinosis in man. This objective is not achieved because of the vagaries of domestic cooking equipment, because some people like their pork rare, and because some pork products – such as certain bolognas – are made from raw pork.

Manifestly a surer way to control trichinosis is to eliminate it from the hog population. This could be done by cooking all garbage fed to hogs, thereby destroying trichinae in the garbage. The procedure is an entirely practical one, and is used in some locations. Indeed federal government regulations now require the cooking of all garbage for hog feeding transported across state lines. The United States Department of Agriculture and the United States Public Health Service are encouraging local legislation, to make the cooking of garbage for hog feeding universally mandatory.

The sad story of trichinosis in the United States points up the importance of animal diseases transmissible to man. Since animal diseases are the province of the veterinarian, this professional man now has stepped beside the physician as an essential member of the public health team. Therefore it is heartening to note that today many veterinarians are pursuing graduate degrees in schools of public health.

[*] 43:1174-1175, No. 9 (September, 1953).

Organic Scintillators

During the first 20 years of this century scintillation counting of alpha particles and protons from nuclear disintegrations was a standard technique. The operator of a spinthariscope sat in a darkened room, peered into a low-power magnifier and recorded tiny flashes of light which were visible when a fluorescent screen of zinc sulfide was struck by an alpha particle or proton. As electrical methods of detecting these particles were developed, the optical method of measurement fell into disuse. After World War II scintillation counting was reinstated as an effective measuring method by substituting an electron multiplier for the eye of the human observer. About the same time, it was found that the photomultiplier was sufficiently sensitive to respond to the very weak scintillations produced by beta and gamma rays in organic compounds such as naphthalene and anthracene, and in transparent inorganic crystals such as sodium iodide containing traces of thallium iodide.

Because the combination of an electron multiplier tube and organic scintillator had an extremely rapid response (approximately 10^{-8} second), nuclear phenomena never before accessible could be studied. As usual when a new field of research opens up, the need for pushing the observational techniques a little further becomes apparent. Consequently the physicists, who were largely responsible for these developments, tested a number of organic compounds for scintillation properties. Two additional compounds, stilbene and terphenyl, were found to be useful but a number of conflicting reports appeared on the relative merits of various compounds.

In order to establish the relative effectiveness of a number of organic scintillators and to determine what features of an organic compound were responsible for its behavior as a scintillator, a project to study promising materials was undertaken by the Department of Chemistry and the Laboratory for Nuclear Science, with financial support by the U. S. Atomic Energy Commission and the Office of Naval Research. The work was carried out by Raymond C. Sangster, '51, A.E.C. predoctoral fellow and later a postdoctoral fellow in Chemistry under the supervision of John W. Irvine, Jr., '39, Associate Professor of Chemistry.

A purification technique was developed which operated on a semicontinuous basis involving differential solution, adsorption, and crystallization. Anthracene was used as a test material in developing the process and all grades of this material from a 95 per cent technical grade to "scintillation grade" could be brought to the same state of purity which was higher than that of the commercial scintillation grade anthracene. Such purified anthracene was used for reference against which other materials were compared under carefully standardized conditions.

Approximately 60 compounds were purified and tested. These compounds were selected as members of several homologous series so the effect of structural changes on the scintillation behavior could be evaluated. Several compounds such as quaterphenyl, 1,2-di-(alpha-naphthyl)-ethylene and carbazole gave substantially larger pulses than stilbene and terphenyl, but no compounds exceeded anthracene.

Geologic Time Measurements

THE continents have reached their present size and form by a series of great mountain-building events, which resulted in lighter masses of rock remaining in gravitational equilibrium high enough above the ocean floors to be exposed above the surface of the water. Thus the continents make a mosaic of areas, each of which was formed during some limited interval of time in the past. A study of the history of the earth and the continents requires that the time and duration of these events be measured, and the events correlated from one continental area to another, in order that the history of the earth's surface may be understood as a unified single progression.

Several methods of measuring the ages of rocks and minerals are being tested in the Department of Geology and Geophysics. All of these are based ultimately on the radioactive decay of some naturally occurring unstable isotope. In the uranium series alone, several ratios of elements or isotopes change progressively throughout time within a closed system, which is generally a single crystal of a mineral containing uranium. Lead 206 increases with respect to uranium 238, lead 207 with respect to uranium 235; and since the two parent elements are isotopes and therefore have a quite constant relative abundance, the lead products have a uniformly changing relationship with respect to each other. Helium also accumulates at a rate proportional to the abundance of the uranium, and may be used in cases where the mineral retains it. For the thorium series lead and helium ratios may also be used. In minerals containing sufficient rubidium the ratio of Sr^{87} to Rb^{87} may be used because the rubidium 87 isotope decays radioactively into strontium 87. Most rocks contain a considerable amount of potassium which generates argon 40 from the decay of the isotope potassium 40.

Mass spectrometers are being used to measure the isotope ratios needed in this work. The Department has an instrument for isotopic analysis of gases, and another instrument recently put into operation for the analysis of solid samples utilizing the emission of ions from a heated filament. Total lead measurements are made by emission spectrography. Gases such as helium and argon are analyzed volumetrically, or by isotope dilution techniques. Uranium and thorium are measured by radiometric techniques.

The patterns of ancient events shown by the results of measurements at M.I.T., and elsewhere, are beginning to resolve the early history of the earth. The ages of different continental areas range from a few million years to about three billion years. No unquestioned measurements have shown any crustal rocks to be older than three billion years, although several areas in different parts of the earth have been close to this figure. Thus it seems probable that this limit sets the approximate time at which continental crustal materials first appeared, or at which the surface was stable enough to permit these masses of material to persist at the surface. Subsequent events show the small continental nuclei growing in size by a series of mountain belts added to the periphery of the existing areas. These belts are now eroded to near sea level, with only their roots left.

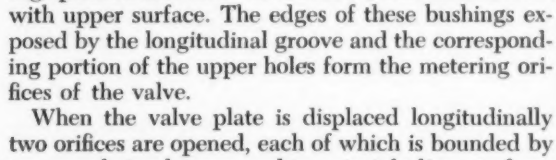
One part of the work of considerable interest involves the measurement of the slowly changing ratio of the strontium isotopes throughout time in the oceans owing to the continuous addition of strontium 87 fed by the breakdown of rubidium 87 in continental rocks. This changing ratio is being measured in samples of marine sediments of different ages. The variation of the ratios of low-mass stable isotopes is also of interest in the study of the history of the chemical elements after they have reached the earth.

Precision Valves

MUCH of the difficulty of making precision control valves for hydraulic or pneumatic systems arises from the difficulty of machining the piston or spool-type valves which are commonly employed. A valve configuration to simplify construction and reduce manufacturing cost of precision control valves has been developed by Shih Y. Lee, '43, Assistant Professor of Mechanical Engineering in the Institute's Dynamic Analysis and Control Laboratory.

A schematic diagram of the new valve design is shown in the diagram below. The valve plate and body are initially rigidly clamped together, and holes *a-a'* and *b-b'* are drilled, bored, and finish-lapped before the two parts are unclamped, thus assuring proper orientation of the metering edges of the valve. Holes *a* and *b* at the top of the valve plate are plugged up. A groove of width, *w*, is milled in the body and bushings pressed into holes of *a'* and *b'*, are finished flush with upper surface. The edges of these bushings exposed by the longitudinal groove and the corresponding portion of the upper holes form the metering orifices of the valve.

When the valve plate is displaced longitudinally two orifices are opened, each of which is bounded by two equal circular arcs and two straight lines, to form curved "parallelograms." The areas of the two are equal and independent of the diameters of holes *a* and *b* so long as their diameter is greater than *w*. If width *w* is constant, the areas of the orifices are proportional to the displacement.



Design for precision valve provides for accurate control of flow in hydraulic or pneumatic systems. Manufacturing operations are simplified and costs are greatly reduced by the new design in which flow is controlled by sliding the valve plate relative to valve body.

Tired Nature's Sweet Restorer

The Basic Mechanisms of Sleep Are Not Thoroughly Understood, Although the Emotional and Psychic Effects of Sleeplessness Are Profound

By FREDERIC W. NORDSIEK

"It is no small art to sleep," wrote Nietzsche, "to achieve it one must keep awake all day." This paradox is firmly inherent in contemporary life. Thus modern superhighways lull some drivers into slumber; witness news accounts of accidents on any major turnpike. Yet the same people who doze off behind the wheels of their cars may need to resort to sleeping pills at bedtime. In short, today's dilemma may be: Benzedrine to keep awake and barbiturates to go to sleep.

To view this dilemma in full perspective we need to know: What is sleep? Is sleep really necessary? What determines when we sleep and when we wake? What aids are available to promote sleep or to promote wakefulness?

The *Iliad,* written down in the Eighth or Seventh Century before the Christian era, calls sleep "the twin of death." This metaphor, though ancient, reflects remarkably well modern physiological knowledge of sleep. For example, after about four hours of continuous slumber, the metabolism of the human being falls off to less than 0.25 calorie per minute; this is the metabolic rate of a dying person. During sleep the systolic blood pressure decreases to less than 100 millimeters of mercury. Speed of circulation of the blood, pulse rate, secretion of digestive juices in the stomach all slow down. Breathing is shallower; volume of air inspired is halved. There is a general depression of tissue and organ activity, and a diminution of muscle tone. The output of urine decreases but that of perspiration increases. Most significant of all – as will be shown presently – there is a pronounced drop in body temperature during slumber. This is about all that is known concerning sleep. Its salient feature, unconsciousness, is little understood at present.

Obviously people must stay awake for some hours at least out of the 24; for it is through physical and mental activity during times of wakefulness that the food, clothing, and shelter from the elements necessary for survival usually are gained. How about staying awake all of the time? But everyone knows that sleeplessness leaves the human being mentally, emotionally, and physically debilitated. Indeed personality effects of extended sleeplessness observed in soldiers have been recorded as irritability, loss of memory, inattention, apathy, foolish garrulity, and irrelevant laughter. The mental disorganization caused by prolonged sleeplessness may verge on temporary insanity.

Objective measurements have been made of the effect of sleeplessness on intellectual capacity. Subjects lacking sleep made lower scores on intelligence tests than normally; and they were found by accurate energy output measurements to expend excess physical work in doing a given intellectual task. Research has shown that reaction speed, muscular steadiness, and accuracy in mental tasks (such as computation) all suffer with sleeplessness. Persons accustomed to about eight hours of sleep were found to regain normal reaction speed and muscular steadiness after about four hours of continuous slumber; but they required at least six hours of sleep to restore normal accuracy in mental tasks.

Thus the emotional and psychic effects of sleeplessness are profound. But if sleeplessness be extended, grave physical effects follow. This fact is known through experiments with animals, where continued deprivation of sleep ultimately kills. Thus young dogs, prevented from sleeping, died in less than a week. Yet animals of the same species and age, allowed to sleep at will, survived for over a month without food. Edna St. Vincent Millay reflected the general misconception of this relationship when she wrote "eat I must and sleep I will." Sleep we *must,* and for maximal well-being we need to spend about a third of our lives asleep.

Day and Night

The human being in general is a diurnal animal, meaning that he is active during the day and sleeps at night. This custom arises from the practicality of using daylight, rather than artificial light, for work. But, since "some must watch while some must sleep," policemen, transportation workers, restaurant employees, and others may find it necessary to reverse the usual pattern and sleep daytimes.

Of primary importance is the ratio of time asleep to time awake, irrespective of the length of each sleep period or when, by the clock, it occurs. In terms of the 24-hour cycle imposed upon us by the earth's rotation, most human beings need to sleep about eight hours in 24. That the 24-hour cycle is not mandatory, however, was shown by Nathaniel Kleitman and Bruce Richardson, physiologists of the University of Chicago, when they lived for some time in the Mammoth Cave in Kentucky. They chose this site for sleep studies, using themselves as subjects, because daylight, temperature fluctuations, and

other environmental variations related to the 24-solar day are excluded from the cave. They observed sleep and wakefulness, and related physiological phenomena, in 21-hour "days," using artificial lighting to simulate the illumination of a sun swinging through a 21-hour cycle. (In such 21-hour days, the sleep pattern becomes seven hours of slumber, 14 hours of wakefulness.) They also studied lengthened days of 28 hours.

Richardson readily adapted to either shortened or lengthened cycles, sleeping well during the "nights" and being energetic during the "days." Kleitman, contrariwise, could not adjust easily. He continued for some time to feel sleepy or alert according to the usual 24-hour cycle, not according to the artificial cycle in effect at the moment.

Hot and Cold

Kleitman and Richardson discovered that their relative adaptability to the sleep patterns of days of various lengths stemmed from their respective ease in changing their body temperature cycles. It has already been remarked that the human temperature falls during sleep. This statement may have surprised readers who, aware that the graduations on all clinical thermometers change from black to red at 98.6 degrees F., have thought of the normal human body temperature as a fixed quantity. The temperature of the healthy human being actually varies within a range of a degree or two, in well-defined cycles. Thus one cycle, in mature women, is a lunar month in length and is related to ovulation. But human beings of both sexes have a marked daily body temperature fluctuation, following a regular, fairly smooth, wave-like curve of a sinusoidal type. The highest temperature occurs about the middle of the hours of waking; the lowest about the middle of the hours of slumber. Note that sleeping habits, not the solar day, determine this relationship. In people who sleep at night, the minimum body temperature occurs during the wee small hours. In those who sleep during the day, the lowest temperature occurs then. Therefore, the temperature cycle of each individual is clearly an artifact, a product of habit; not the result of direct environmental influences of the solar day.

If adult human beings stay awake for several days on end, their daily temperature fluctuation continues; and they usually feel sleepiest when the body temperature is at its minimum, about the middle of their normal sleeping time.

On the basis of what has been told about the temperature cycle, it will not surprise the reader to learn that it can be reversed, shifted, lengthened, or shortened. But individuals differ widely in the ease and speed with which they can make such changes — just as most human characteristics show a wide range of variability. Thus, during the Mammoth Cave sleep studies, Richardson readily shortened or lengthened his temperature cycle to correspond to the experimental 21-hour or 28-hour days. Kleitman, in contrast, was much slower to change the length of his temperature cycle. Therefore, whether the day was lengthened or shortened, he experienced, at first, occasions when his minimum body temperature occurred during hours when he was required to stay awake; and he felt miserable accordingly.

Shifts in the body temperature cycle result when people move from one time zone to another. Crossing the ocean by steamer allows gradual adaptation to the changing time; but individuals who travel from Europe to America by airplane abruptly find their body temperature cycle five hours "out of phase" with the sleep pattern required by the local solar day. The necessary adjustment takes a few days, and again is easier for some than for others, depending upon the adaptability of the individual.

Workers who have alternating stretches of day and night duty — such as some policemen — have to reverse their temperature cycle every time they change their work schedule. Such a complete reversal may take a week or more.

And So to Bed

Although Mark Twain advised against going to bed "because so many people die there," reclining in a dark, quiet room, on a comfortable bed with covering suited to the season, unquestionably promotes sustained slumber. The reference to darkness and quiet points up a prime requisite for sleep; absence of stimulation. Slumber of a sort is possible in a Pullman berth with all of the senses continually assailed; but such sleep is fitful at best.

Mental and physical relaxation, a static position, darkness, quiet, absence of pronounced odors, a comfortable temperature (perhaps achieved through air conditioning in the summer), a comfortable bed (according to individual preference) — all of these aid sleep. Beyond a few such basic facts lies a vast and ambiguous folklore concerning how to sleep well. Thus opinions differ broadly on how to accomplish the necessary mental and physical relaxation; as to the relative virtues of soft versus hard beds; whether a pillow should be used and its optimal thickness and resiliency; whether warm baths help; whether eating or drinking at bedtime should be practiced or shunned, and so forth. Children may find sleep impossible unless they are kissed and tucked in, or unless they take a particular favorite toy to bed. Books could be written (indeed have been) about this great twilight land of mingled fact and fantasy concerning aids to sleep.

One solid area of scientific fact concerning aids to sleep and wakefulness is the pharmacology of the drugs that promote either condition. All of these are classified as drugs that affect the central nervous system. Those that promote wakefulness are called stimulants: those that promote sleep are included among the central nervous system depressants.

The depressants are classified in various ways. One classification divides these drugs into four groups: general anesthetics (such as ether), intoxicants (such as alcohol), antispasmodics (such as belladonna), and hypnotics — the drugs that promote sleep. A five-part classification of central nervous system depressants is: sedatives, pain-relieving agents, cough-relieving agents, ego-depressing substances (used in narco-analysis), and hypnotics. But all of the depressant

(*Continued on page 420*)

The Future of Discovery and Invention

With its Emphasis on Application and Group Effort

Rather than on Basic Discovery and Individualism

Science will Play a Leading Role in Invention

By J. L. B. BLIZARD

At present colleges graduate each year as many engineers* as formed the entire profession in 1900.[1] Since the turn of the century the engineering profession in the United States has increased from only 40,000 to more than 400,000 members, and research expenditures have skyrocketed. It might be expected that the patents issued per year would have increased during this period. But United States Patent Office statistics[2] show that the patent rate has not continued to increase, nor has it even remained constant. Discounting short-term fluctuations, the patent rate has been decreasing for the last 20 years. (See Figs. 1 and 2.) The decline in patenting appears to be international in scope – patent trends in England, France, Germany, Canada, and Japan have been similar to those in the United States.[3]

What is really of interest is the number of inventions, which is not necessarily indicated by the number of patents. Changes in patent policy, formation of patent pools, and growth of monopoly would presumably affect the proportion of inventions that are patented. Yet the international aspect of the decline suggests that a more fundamental change is taking place, which involves invention itself, and not just patenting.

Stafford[3] recently made a study of more than 1,100,000 U.S. patents to determine trends in the last few decades. From this study it became apparent that not only had the patent volume declined, but that the patent classification system had almost completed its growth:

"The development of the classification system for patented invention since 1838 indicates that the number of main classes in invention increased at approximately an exponential rate during the Nineteenth and early Twentieth Centuries. From 22 main classes in 1836 the classification system increased to 290 in 1919. Only 11 main classes were added between 1919 and 1947.

* Please see numbered references at end of article, page 422.

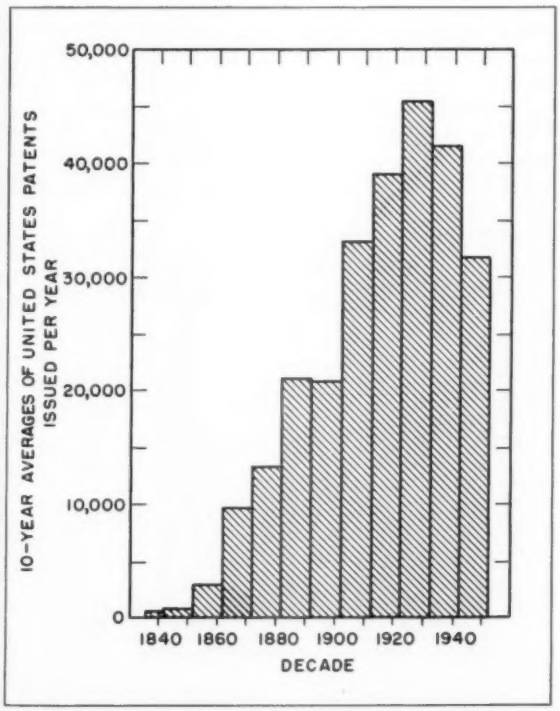


Fig. 1. United States patents; 10-year averages. Source: Statistical Abstract of the United States, *1952, pages 456–458.*

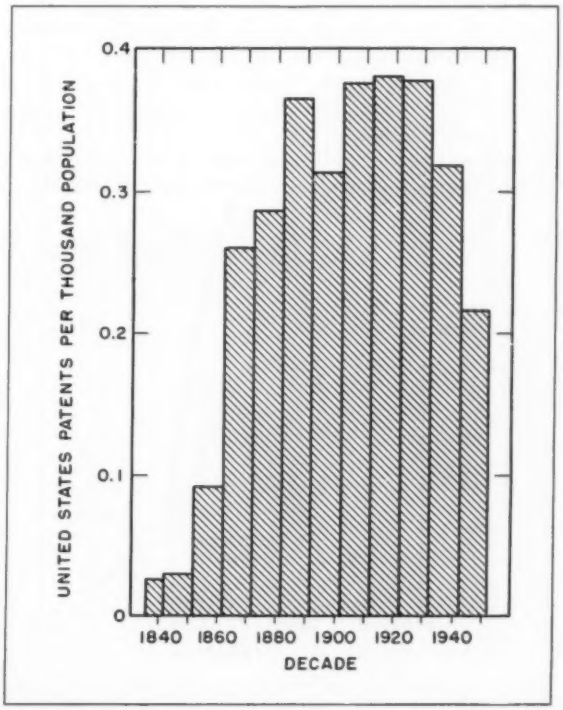


Fig. 2. Patents issued per year per capita. Source: Statistical Abstract of the United States, *1952; census data, page 4.*

"About 1870 the increasing complexity of invention within the main classes required their sub-division into sub-classes. Between 1870 and 1924 these sub-classes increased at an exponential rate to a total of 30,000. Since 1924 the total has increased at a slower rate to 43,500 . . .

"These trends within the classification system indicate that the numbers of categories required to classify material culture are increasing at decreasing rates, the growth of main classes or large cultural complexes having almost stopped. The broad outlines of technology may now be at hand, with only a vast amount of improving innovation to be supplied in the future."

Stafford noted further that the decline in patents had been greatest in the fields of mechanics and the practical arts – areas which had been exploited the longest. Least affected had been the yield of patents from new developments in chemistry and physics.

In any given field, discoveries or inventions usually follow a cycle of growth and decline (Figs. 3 and 4) which, on the average, resembles a bell-shaped curve. The cycle begins with a group of important fundamental discoveries or inventions, after which numerous additions, improvements, and refinements are made.

Thus, even more significant than trends in the total number of inventions would be the trend in fundamental inventions. Some time ago the editors of *Scientific American* estimated the number of fundamental inventions made in various decades in the United States (Table 1).[4]

The world-wide growth of technology (including science) has been traced by Darmstaedter.[5, 6] With the co-operation of 26 specialists, he has charted the distribution of important discoveries and inventions in different periods and in different countries. (Fig. 5). It appears that the exponential growth of the Eighteenth and Nineteenth Centuries is leveling off, and possibly even declining.

Sorokin, the sociologist, correlates as follows the respective growths of science and technology:

> Technological progress (as measured by the numerical increase of inventions) has been more rapid for the last two centuries than scientific advances. Indeed the number of important discoveries in the sciences increased from 111 in 1701-1725 to 1,617 in 1876-1900, that is, about 15 times; the number of inventions for these two periods respectively was 47 and 1,223, representing an increase of about 26 times. The number of significant scientific discoveries in 1876-1900 was about 2.3 times as great as in 1801-1825; the number of technological inventions,

TABLE 1

Estimate of the Number of Fundamental Inventions in the United States from 1846-1915. Source: *Scientific American*, **CXXIII**: 323-325.

Period	*Fundamental Inventions*
1846-1855	25
1856-1865	24
1866-1875	20
1876-1885	16
1886-1895	13
1896-1905	15
1906-1915	10

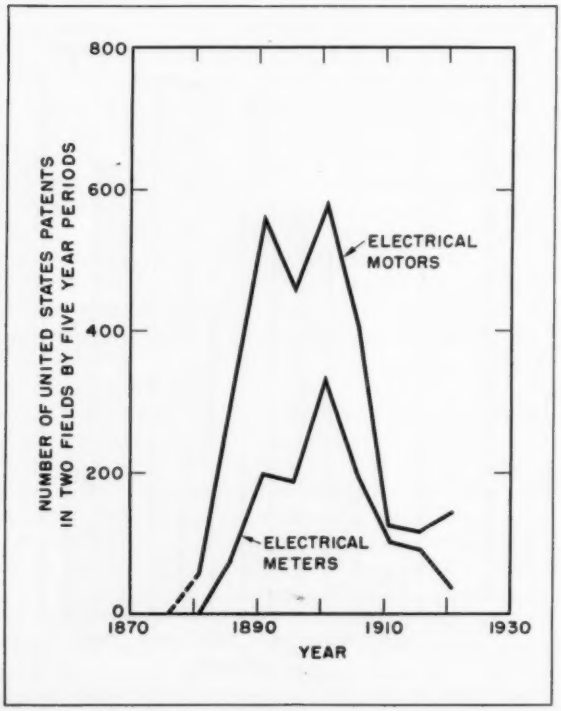


Fig. 3. Patents issued, by five-year periods, 1879-1923. Source: Kuznets' Secular Movements in Production and Prices.

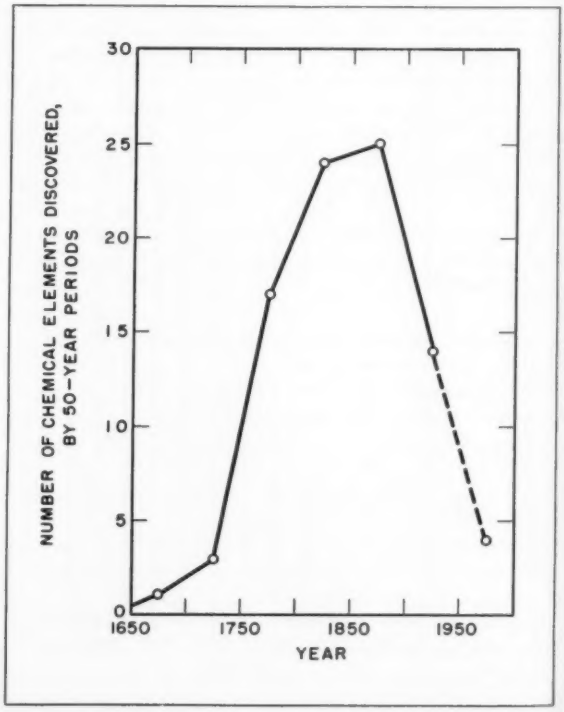


Fig. 4. Discovery of the chemical elements, by 50-year periods. Source: World Book Encyclopedia.

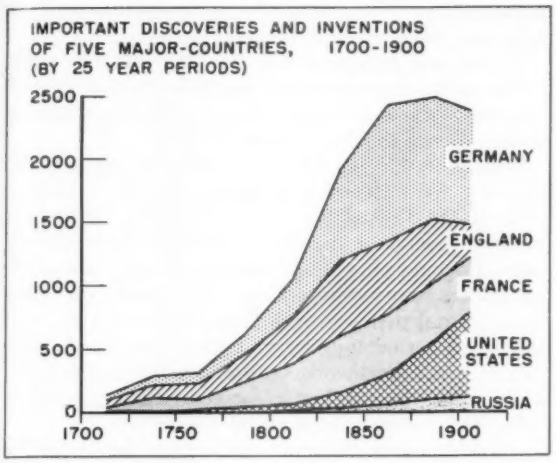


Fig. 5. Important discoveries and inventions of five major countries, 1700–1900, by 25-year periods. Data for 1900–1908 has been normalized to a 25-year period, and is shown as dashed lines. Source: Sorokin's Social and Cultural Dynamics, *Volume 2, page 165.*

however, was about 3.2 times as great in the latter period. Hence, if in the Twentieth Century there is a slackening in the numerical increase of inventions, it is highly probable that this slackening is as pronounced or perhaps even more marked in the natural sciences.[6]

Having glimpsed the historical development of technology, it would be interesting to speculate upon the future. Stafford's analysis of patent trends indicates that fundamental inventions will arise increasingly from the sciences. The future rate of development of technology can thus be approximated by a study of the growth of present day science in leading countries.

Recent wars and upheavals have contracted European scientific contributions. It might be expected that contributions from the United States, with its abundant resources, high standard of living, and, above all, its high level of education, would more than compensate. M. H. Trytten, Director of the Office of Scientific Personnel,[7] states:

At the close of World War II everyone agreed that the United States, whose contributions in the past had been mainly in the field of technology, should turn to much more emphasis on basic research. In Europe, which had been the major source of the world's great scientific progress during the past two centuries, the scientific enterprise had been all but destroyed and work had almost stopped. Without further progress in scientific discovery, technology would soon reach a dead end. It was obvious to the nation's leaders, including those in government, that the United States must take the leadership and shoulder the responsibility for the march of fundamental discovery. Programs for the expansion of basic scientific work in the United States were laid down in several official reports.

In spite of all this the trend since the war has gone in the opposite direction: the emphasis has actually shifted more and more to applied science rather than basic science. An increasing share of the nation's research funds has been spent in engineering and development work. And with the funds have gone the scientists. An even larger proportion of them have been drawn into programs that are mainly applied research, if indeed they can be called research at all. In fact, many of our most productive scientists have abandoned research altogether and become administrators or policy makers.

Nine tenths of the research money spent in the United States in 1947 (excluding atomic energy) went for applied science,[8] and the proportion has since become more and more exaggerated. The trend holds true even for educational institutions, which have long been the stronghold for pure science. From 1951 to 1952, the basic research funds in colleges decreased by nearly $4,000,000 while their applied research funds increased by $30,000,000.[9]

How abundant were American contributions to basic science before the conversion to applied science? For an objective comparison of basic science in various countries two sources will be cited: (1) Thorner's[10] list of important discoveries and inventions by country of origin for the 25-year period with mid-point 1900, and (2) Nobel prizes in the physical sciences from 1901 to 1953.[11] The Nobel prizes in the sciences are awarded impartially for important discoveries, theoretical pronouncements, and occasionally for scientific inventions (for example, to Marconi in 1909

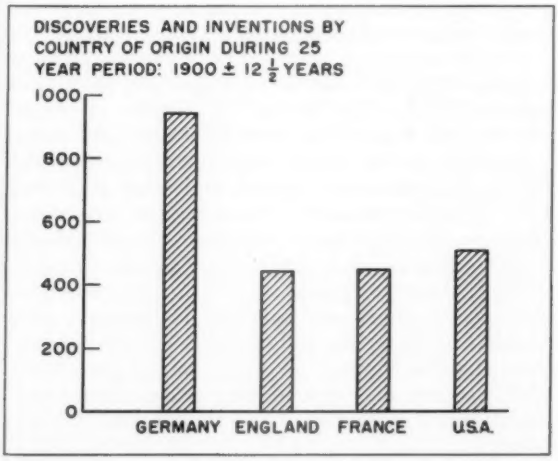


Fig. 6. Discoveries and inventions by country of origin during 25-year period, with mid-point 1900. Source: Thorner, American Journal of Sociology, *LVIII:25.*

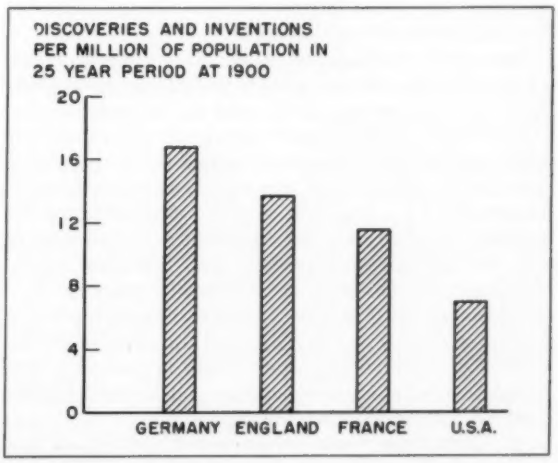


Fig. 7. Discoveries and inventions per million of population in 25-year period at 1900. Source: Thorner, American Journal of Sociology, *LVIII:25.*

for wireless). Since 1901 when the first awards were given, there have been 115 prize winners in physics and chemistry. Such a number can provide an indication of recent scientific activity in various countries. (See Figs. 6, 7, 8, 9.)

The nation most prominently represented among the Nobel science winners has been Germany, with England second, and the United States third. But it must be remembered that the 1925 population of the United States totaled more than England and Germany combined. Per capita the United States ranks seventh in prize winners (Fig. 9 and Tables 2 and 3), even if physiology prize winners are included. (Physiology is a strong field in American research.)

Even more surprising, the United States is still outranked by European nations having far smaller proportions of college students. Compare England and the United States. The enrollment of the 16 English and Scottish universities in 1930 was 0.11 per cent of the population of England, Scotland, and Wales.[12] In the same year the 900-odd American four-year colleges and universities had enrollments totaling 0.90 per cent of the population of the United States.[13] Per college graduate (at 1930 rates) England thus leads the United States some 15 to 1 in Nobel prize recipients. Of course, the average American college education is not necessarily the equivalent of the average British university education. Yet the United States has produced a high proportion of scientists. Since 1910, nearly every year more than half of the Ph.D.'s granted in the United States have been in the field of science.[14]

Thus despite the high level of education in the United States (see Table 4),[15] fewer discoveries and inventions have resulted, relative to the size of the population, than in many European countries.

What accounts for the divergence between European and American scientific productivity? The distribution of intelligence in these countries is not significantly different, and the proportion of talented people who complete college is far higher in the United Stated than in any cited European country. Factors other than intelligence and education must be particularly influential. In order to understand this problem, let us first inquire into the characteristics of the successful research scientist.

Recently a psychologist, Anne Roe, studied a group of eminent American scientists to discover what traits they had in common. In the past it was generally assumed that original work in science required very high intelligence. The group studied by the psychologist, on the other hand, showed a surprisingly wide range of I.Q.'s – from 121 to 177 – starting *below* the median I.Q., 123, of college graduates.[16] (The median I.Q. of Ph.D. scientists is about 141.[16]) While "genius" intelligence is certainly an asset in the scientific field as elsewhere, it is still not characteristic of the entire group of discoverers and original thinkers. But these scientists do have important traits in common. The psychological study showed that each of the scientists had the following characteristics:

1. *Motivation:* Each person tested had "compelling reasons for becoming a scientist."[16]

2. *Hard Work:* "They have worked long hours for many years, frequently with no vacations to speak of, because they would rather be doing their work than anything else."[18]

3. *Personal Independence:* ". . . all this may point to the most important single factor in the making of a scientist – the need and ability to develop personal independence to a high degree."[16]

It may be that the necessary character traits of the scientist are fostered to a higher degree in Europe than in the United States. Consider the differences in the educational systems – American high schools, geared to mass education, meet fewer hours per week, assign less homework, and provide about two years' less material than European secondary schools. As if that were not enough, there is great pressure here to eliminate all homework, on the grounds that it interferes with the student's extracurricular activities. What is the effect on the gifted child?

"The high school seldom challenged the student of first-rate ability to work up to the level of his intellectual powers . . . The result was that many a brilliant mind developed habits of laziness, carelessness, and superficiality. These habits, becoming firmly established during adolescence, prevented the full development of powers. Even the conscientious student of superior ability did not often find himself seriously involved in a great intellectual enterprise. Seldom was any student 'set on fire' intellectually, eager to explore on his own, ready to conquer difficulties and go through whatever drudgery might be necessary to achieve his purpose. The individual and society were both losers."[17]

The author is reminded of a brilliant scientist who might have left school at 15. The high school work was too slow and dull for him, and his average was D. But one lone teacher recognized his potentialities and encouraged him to prepare for college. After graduating from college he completed a Ph.D. in physics and went on to become codiscoverer of a new subatomic particle. Dr. Roe was amazed to find that many members of her eminent group had become scientists quite by accident. With the present shortage of scientists and engineers, such haphazard development of talent is unrealistic. One of the most crucial factors in the cold war has become the recruitment of technical personnel – Russia is now training more scientists and nearly twice as many engineers as is the United States.

It is interesting to compare the attention given to unusual children in the Soviet Union and the United States. The U.S.S.R. intensively screens all school children for talent, and provides every educational advantage for the bright ones (in technical fields). Slow or handicapped children and other unproductive misfits are ignored. The American educational system on the other hand is solicitous toward retarded children and largely indifferent toward the gifted. In 1952 the American public schools provided five times the special educational facilities for mentally slow children as for the mentally gifted.[18] The earlier practices of grade skipping or acceleration for the talented child are now disapproved, since social development has assumed more importance than mental development.

What about personal independence, which was rated as the most important trait of the scientist? Subtle changes have come about in the United States.

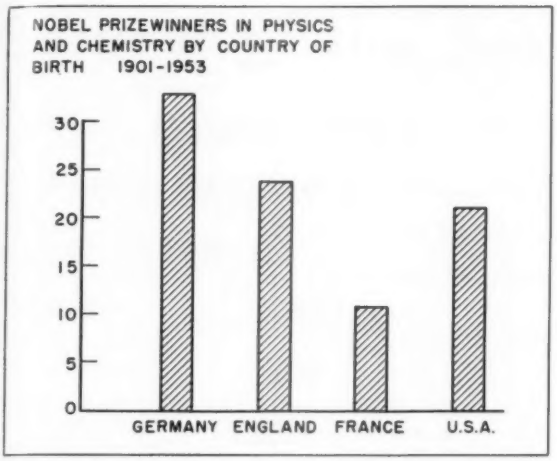


Fig. 8. Nobel prize winners by country of birth; physics and chemistry, 1901–1953. Source: World Almanac, *1953, pages 593–594.*

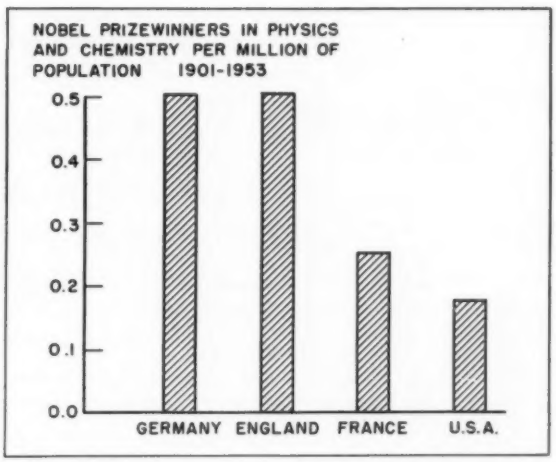


Fig. 9. Nobel prize winners per million of population; physics and chemistry, 1901–1953. Population as of 1925. Source: World Almanac, *1953, pages 593–594.*

As one manifestation, traditional rugged individualism is being shelved in favor of a new virtue, "integration within the group." It is now stressed that the individual's interactions with the group are of greater importance than his intrinsic talents or abilities. Indoctrination on this score has been going on for some time under the banner of progressive education. Group activities have largely supplanted individual endeavors in early training.

The trend away from individuality may have considerable effect on scientific productivity. The psychologists[19] describe the change as follows: Western civilization since the Renaissance has been in a stage of continuous expansion in population, means of production, colonization, exploration, and the like. Such a society appears to be dominated by an *inner-directed* personality. The individual is encouraged to develop his latent abilities and to go into the world to seek his fortune. In the presently developing phase of population stability, a new type of individual becomes predominant – the *other-directed* personality. His psychological motivation is less for individual achievement and more for the approval of the group.

TABLE 2

Nobel Prize Winners in Physics, Chemistry, and Physiology for 1901-1926. Population Base: 1900. Quotas Give Distribution Expected on Basis of Population. Countries Having 5 or More Prize Winners Included. Source of Population Figures: Kuczynski's *Measurement of Population Growth*, pages 230-231.

Rank	*Country*	*Quota*	*Prize Winners*	*Per Cent of Quota*
1	Holland	1.6	7	437
2	Sweden	1.5	5	353
3	Denmark	1.2	4	333
4	Switzerland	1.0	3	300
5	Austria	1.8	3	167
6	Germany	15.4	23	150
7	England	11.7	11	94
8	France	12.3	10	81
9	United States	23	3	13

TABLE 3

Nobel Prize Winners in Physics, Chemistry, and Physiology for 1927-1953. Population base: 1925. Quotas Give Distribution Expected on Basis of Population. Countries Having 5 or More Prize Winners Included. Source of Population Figures: Kuczynski's *Measurement of Population Growth*, pages 230-231.

Rank	*Country*	*Quota*	*Prize Winners*	*Per Cent of Quota*
1	Switzerland	1.2	5	417
2	Austria	2	6	300
3	England	13	21	160
4	Germany	18.8	19	101
5	Denmark	1	1	100
6	Holland	2.2	2	91
7	United States	33.6	27	80
8	Sweden	1.8	1	56
9	France	12	4	33

TABLE 4

Higher Education in Various Countries. Source: *Statistical Yearbook of the United Nations*, 1952.

Country	*1952 Population*	*Students in Higher Educational Institutions in 1952*	*Per Cent*
U.S.A.	150,697,361	2,659,021	1.76
Canada	14,009,000	69,022	0.49
England Wales	44,020,000	103,081	0.23
France	41,944,000	138,000	0.33
West Germany	47,674,000	109,604	0.23
Switzerland	4,690,000	16,501	0.35
Sweden	7,017,000	16,906	0.24
Netherlands	10,114,000	28,250	0.28
Italy	46,280,000	146,485	0.32

TABLE 5

Productivity of Physicists in Rural and Urban Areas. Source: Haberly in *Physics Today*, 6:13.

Locale of Early Education	*Production Index of Physicists*
Rural	0.58
Population under 2,500	2.40
Population 2,501-50,000	1.57
Population over 50,000	0.97

TABLE 6

Per Cent of College Graduates Earning over $5,000 a Year in Various Professions in 1947. Source: Havemann and West's *They Went to College*.

Occupation of College Graduates	*Per Cent Earning over $5,000 a Year*
Business Administration	82
Medicine	71
Law	63
Dentistry	63
Engineering	52
Government Service	38
Science	26
Education	19

Statistically, the other-directed personality predominates in cities and suburban areas, where success depends largely upon interaction with people. The inner-directed personality is found mainly in semi-rural areas, where the principal struggle is with the physical, rather than the human, environment.

Could such a change in attitude affect the proportion of people who might become successful scientists? A recent study of the origins of more than 700 physicists discloses that two and a half times the proportion of physicists per capita were born and raised in small towns as in large cities (Table 5).

In the apt terms of psychologist Riesman, the inner-directed person is equipped with a psychological gyroscope, which is set spinning with the proper speed and direction early in life, and which is relatively insensitive to the buffetings of environment. By contrast, the other-directed person has a delicately tuned radar, by which he receives signals from the fluctuating authorities of his environment. Thus, while the inner-directed person is capable of pursuing a long-term objective (research) the sensitive other-directed person is often too involved with his human adaptation to consider more than immediate goals. And while an earlier rural-bred generation of Americans showed a spirit of venture and initiative in vocational pursuits, the high school or college graduate of today wants to play it safe by finding a niche in a large, established corporation.

Studies have been made of the collegiate training of successful scientists and engineers. In the case of the scientists, a search was made of the undergraduate origins of the doctors of natural science listed in *American Men of Science*.[20] Amazingly enough, the highest proportion of scientists come from institutions in the agrarian Midwest, followed by the Far West, East, and South, in that order. In the case of the engineers, the college backgrounds of men listed in *Who's Who in Engineering* were ascertained.[21] (As an interesting aside, M.I.T. leads all other technical schools, not only in total number of listings, but in the percentage of alumni listed.) Of the 50 institutions with the largest number of listed alumni, 22 are in the East, 21 in the Midwest, and only 4 and 3 in the Far West and South, respectively.

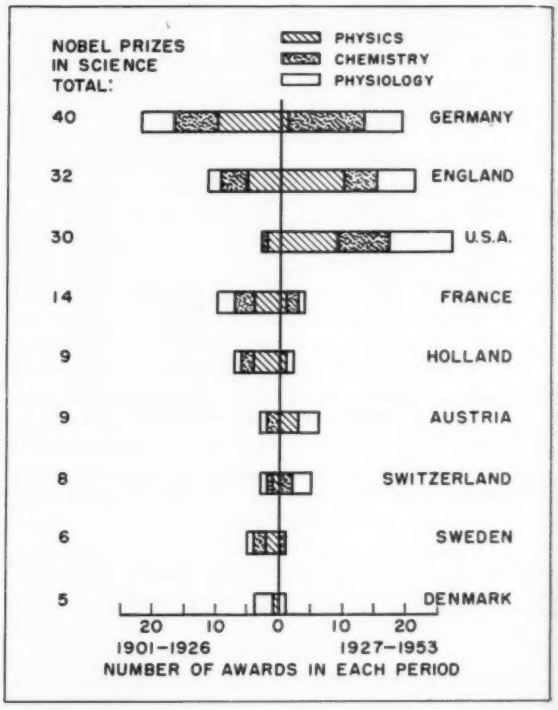


Fig. 10. Nobel prize winners in physics, chemistry, and physiology during 1901–1926, and 1927–1953. Source: World Almanac, *1953, pages 593–594.*

The group which analyzed the origins of scientists states:

"Our evidence indicates that high-cost institutions [universities] attract a relatively wealthy clientele who seldom pursue the economically unrewarding vocation of professional science . . .

"One may further note that among the first 50 [colleges which produce scientists] there is a great preponderance from the Middle West and Far West. No Southern institutions appear here, and only eight in the New England and Middle Atlantic States . . .

"In the production of graduates entering some other professions, such as the law, the ranking is quite different. According to a survey made before World War II, the United States Northeast is the region most productive of future lawyers; of the 35 undergraduate institutions that lead in this respect nearly two thirds were in New England, New York, and Pennsylvania [these states average 76 per cent urban[22]] . . .

"It is interesting to note in passing that those industrialized regions which offer the greatest vocational future to scientists are not the most productive, whereas the semiagrarian regions of the Middle and Far West produce most abundantly."[20]

(*Continued on page 421*)

Down to the Sea in Ships— FOR PROTEIN!

The Ocean's Bounty Will Help Fill Supermarkets— It May Even Make Major Contributions to Our Chemical and Pharmaceutical Industries

By MILTON E. PARKER

THAR she blows" is the muted cry of a bygone day that conjures up nostalgic memories of old New Bedford, the once renowned whaling port. "A dead whale or a stove boat" was the battle cry that urged her sons on to feats of raw courage when locked in mortal combat with an enraged denizen of the deep. In time, the development of mineral oil for illuminating and lubricating purposes presaged the passing of that glamourous calling which had urged many a daring youth on to a career as harpooner. No cowboy seeking to tame a bucking bronco ever experienced the gyrations and goose flesh that thrilled those hardy men of the sea who rode the waves in the bow of a whaleboat, with weapon sunk deep in the flesh of frenzied prey.

The passing of whaling as the leading industry of New Bedford and San Francisco was surplanted with the onset of more lucrative landlubber pursuits, as our history books reveal. Still "dat ole davil, sea" beckons men. But it now appears that instead of providing illuminating oil, the bounty of the ocean will help fill the larders of our supermarkets and perhaps even make major contributions to our chemical and pharmaceutical stocks. For while the glamour of a former day has passed into the limbo of forgotten professions as eulogized in the works of a Herman Melville, there are evidences that once again our mariners will be called upon to help supply an important segment of the nation's sustenance. And where in the earlier days they went down to the sea for the oil of industry, they now will seek the protein of nutrition!

To many a reader, the suggestion that men will go down to the sea for such a prosaic thing as protein might appear almost sacrilegious to the revered memories of our sturdy mariners of yesteryear. Yet such a mission, commonplace as it may appear by contrast, is probably destined to be even more fateful to our national survival than the whale oil that filled an urgent need of an earlier day in the life of our country. For in the mounting pressure of population – not yet too apparent in the face of certain agricultural surpluses – sea foods are bound to play an ever increasing role (possibly even one of vital significance as one of our most important national food resources). Therefore, while such a role may never seem inspiring in the making of contemporary history, it may become the object of marvel and adoration to future generations – just as past history with its thrilling exploits of the sea are so cherished by us today!

The suggestion that protein – food protein – is anything other than the concern of a chemist or technologist might seem odd at first blush. Actually, food proteins truly occupy a tremendously vital significance in national and world affairs – much more so than is usually realized. A list of the basic materials any individual customarily considers essential for his own comfort, as well as that of his family, will indicate the importance of proteins. For the most part, food, clothing, shelter, medical services, and entertainment materials constitute our basic requirements. Further consideration will reveal that recent developments in research and production have made possible almost unbelievable potentials in the quantity and quality of these needs. Consequently, from the mere physical point of view, essential production facilities can apparently be expanded indefinitely should the demand require it. In other words, we now have the necessary knowledge, and with the necessary machines we could produce these materials to satisfy almost every physical need that might develop – with the single exception of food. But when we start to appraise food production, we soon come to realize that an entirely different situation prevails.

In the light of present knowledge, the only general classification of foods we can justify is on the basis of their five fundamental chemical constituents, namely: proteins, carbohydrates, fats, vitamins, and minerals. Without delving into too many technicalities (which incidentally cannot be dismissed by ignoring them), when we look around the world we will find that vitamins and minerals are needed nutritionally in relatively small quantities, are available in native foods, and can be produced in most countries at relatively low costs. Furthermore, if all the animal fats, vegetable oils and carbohydrates that are available and produced each year in the form of various crops could be fed exclusively to humans, the people of the world would have more than enough for their needs; in fact, there would be more than they could possibly eat. Such a fact can be substantiated by any skeptic from existing records and compilations of the United Nations.

Tremendous Significance of Protein

When all the facts and figures are analyzed, it becomes apparent that there exists in the world today a terrible lack of protein of high nutritive value, such as that found in meat, fish, eggs, and milk, for

New Bedford Standard-Times

"A dead whale or a stove boat!"

example. It does not seem too far-fetched to suggest that the great lack of protein of high nutritive value is the crux of most of the woes of this globe. Whereas in ancient days, wars were fought over rare spices and other food staples, today probably most of our wars could be avoided if there was enough of the proper kind of protein to go around. In other words, we have a world shortage of food only because we have an apparent shortage of the proper types of food protein. The main reason we have a world shortage of the proper food protein is that we have not yet learned how to refine, recover, process, store, and distribute these food elements. True enough we have learned to do these things with our carbohydrates (such as granulated sugar, cornstarch, and chewing gum, for example) – with our fats and oils (such as butter and margarine, shortenings, essential oils used for flavorings, and so on) – with our minerals (such as ordinary table salt), and even with our vitamins such as we can buy over the counter in almost any drugstore today. Yet we do not know how to preserve foods and retain their protein values effectively.

Recently, monosodium glutamate (or "Accent" as one outstanding commercial product is identified) has been suggested for the contents of a third shaker of seasoning on our tables. This purified protein constituent is really an amino acid derivative – and amino acids are the building blocks that make up proteins. Gelatin is another and much older purified protein but, in themselves, neither it nor the sodium salt of glutamic acid, are the proper kind of food proteins to solve nutritional and dietary needs. In other words, aside from these few exceptions (which are really parts of proteins – and not nutritionally essential parts at that) we have not yet been able to assemble or synthesize proteins of meat, fish, egg, or milk; nor have we been able to refine, recover, process, store, and distribute these food proteins as we do other major chemical constituents of foods.

What Are Food Proteins?

Before we can hope to refine proteins, we must first know what they are chemically. Actually, we do refine and even synthesize some vitamins because we have the prerequisite chemical knowledge that enables us to do so. However, proteins are much more complex and do not yield to such ready analysis and synthesis as do the other chemical constituents of foods. Proteins are giant molecules, made up of many different smaller molecular units, or "building blocks," called amino acids. However, they are far from being mere assemblies of amino acids, for other complex biochemical combinations are also involved, just as bricks need mortar in making a building possible.

Nevertheless, we do know that there are certain amino acids that must be present in food if proteins are to satisfy human nutritional needs; such amino acids we term "essential." Actually, a score or more of amino acids are found in our foods. Of these, eight or 10 are considered essential, while the remainder are referred to as "nonessential" since apparently the human body can either get along without them or can synthesize them in its own metabolism.

The quantity and quality of proteins supplied by the diet are of vital importance to an individual's health at every age level. Although the public has heard a lot about the importance of vitamins and minerals as good health factors, it has heard precious little about the significance of the proper amounts and the proper quality of protein. Yet we need vitamins and minerals only in minute quantities each day – in parts per million in most cases, whereas we need appreciable quantities of proteins each day – about one twentieth (or 5 per cent) of our total food bulk. Whenever the total quantity or the average quality of the consumed protein falls significantly below accepted standards for good nutrition, the signs and symptons of protein deficiency may appear. Mild to moderate hypoproteinosis (the medical term for protein deficiency) is observed in the United States according to the results of reliable clinical observations.

Amino Acids and Their Importance

Nutritionists have demonstrated that amino acids are utilized in definite combining proportions. Those food proteins which contain amino acids in approximately the same proportions in which they are utilized in the body are most effectively assimilated by both adults and children. In order to be effectively utilized in the diet, the amino acids must be present in food in the proper proportions as well as the proper amounts. Because foods of animal origin such as meat, fish, milk, and eggs do contain amino acids in the proportions in which they are best utilized in the human body, nutritionists regard such animal proteins as of high nutritional quality. In other words, meat, fish, milk, and egg proteins are superior to the food proteins found in fruits, vegetables, and cereal grains. The same thought could be expressed by stating that, if consumed without milk, most breakfast cereals would be of low order nutritionally. When they are eaten with milk, whole or skimmed, the total protein intake is made available. Still more important

and significant is the fact that the total nutritional value of the combined milk and the breakfast cereal is greater than if the milk and the cereal were consumed and digested separately. The reason for two and two equaling more than four in this nutritional equation is that amino acids in milk are in such proportion and amounts as can contribute to an improvement of amino acid balance in the protein nutrition of any person eating the milk and cereal combination.

Again, it should be emphasized that for most efficient dietary utilization, amino acids must be present in foods in the proper proportions as well as in the proper amounts. Such results can be attained by the following means: (1) use of proper combination of food proteins (for example, cereal protein and milk protein) whose amino acid proportions exert a supplementary effect upon one another; (2) more even distribution of high-quality protein (for example, meat, fish, milk, or egg proteins) among the daily meals; and (3) use of specific amino acid supplements to low quality proteins to achieve amino acid proportions that conform to nutritional needs.

Our National Protein Supply

We, in America, are consuming about 60 grams per person per day of animal protein combined in the meat, fish, milk, and eggs we eat and about 35 grams per person per day of vegetable protein – or a total of 95 grams of total food protein per person per day. Since a pound is equivalent to 453.6 grams, we are eating, on the average, a little more than a fifth of a pound of total food protein per day, on the dry basis. All of our food contains varying amounts of moisture as well as other nutrients, with the result that the average person consumes about five pounds of foods per day – a figure, incidentally, which does not vary appreciably from year to year. Yet it is a good figure to keep in mind, for if you are in the food business, your problem is to find ways and means of getting your share of that five pounds.

Through its Food and Nutrition Board, consisting of eminent scientists, the National Research Council of Washington, D.C., has set up what it calls "Recommended Dietary Allowances" which are in reality objectives toward which one should theoretically aim in planning practical dietaries. According to this source, about 70 grams of protein is the normal daily need for adults, whereas growing children need up to 100 grams per day. However, there are many nutritionists who consider these recommendations too low. Actually, the protein quota of the American soldier's ration in World War II was much more liberal – in fact, it was double the recommended daily allowance or 140 grams. And he ate all of it! In addition, there are several indications that our animal protein intake is below the amount we really desire and below that which is necessary for maximum vigor, disease resistance, and so on. When discussion is confined to the needs of our own citizens in the United States, it would appear that there exists an extensive untapped market for animal protein. The market for domestic consumption would have to be increased about 50 per cent in order that our population may be as well fed as the American soldier is being fed.

One of the main reasons why our present consumption of animal protein is subnormal is that the education of the public on their protein needs has not as yet taken hold. In 1950, 32 per cent of the animal protein production was consumed in all forms of meat, whereas slightly more – or a good third – was consumed in the form of fluid milk, cheese, dry milk, and so on. Approximately 39 per cent of the total milk protein produced in 1950 went into nonfood uses, according to figures released by the U.S. Department of Agriculture – a deplorable waste of food resources, to be sure. This also points to a potential source of food as our population pressure increases. As knowledge of nutrition increases, there will develop a greater demand for animal protein.

U.S. Food Protein Stocks and National Defense

The following preliminary study of the food protein stocks of the United States was made for the purpose of judging the adequacy of such stocks under current world conditions. In recent years, the development of nuclear and bacterial weapons, along with intercontinental bombers presumably capable of delivering them, has created a potential hazard to this nation's food protein resources not yet fully comprehended. The facts that the majority of people of this nation live far from the areas of food production and that about two-thirds of all protein consumed is of a highly perishable nature, suggests a complex situation which must eventually be thoroughly analyzed before any realistic defense program can be effective.

Raymond E. Hanson

The unit cost, as well as the total cost, of food protein is extremely high compared to the cost of the majority of defense metals, and clinical evidence indicates that moderately serious deficiences of high-quality protein nutrition exist among substantial numbers of the American people. This information has helped to point up the importance and urgency of an immediate review of this nation's position and attitude regarding the problem of food protein supply. In furthering this effort, the food protein stocks of the United States have been surveyed and broken down in terms of the number of days' supply of animal and vegetable protein available to the population on certain dates or during certain periods. The values quoted are in terms of estimated disappearance rates. The daily rates are approximately 60 grams per capita (or 10,600 tons for the nation) of food protein of animal origin and 35 grams per capita (or 6,180 tons for the United States) from vegetable sources. A distinct differentiation is made between animal and vegetable protein because of the large differences in their biological nutritive quality or in their ability to satisfy protein hunger when used in the customary manner.

The stocks of animal protein surveyed include those which stood between the farms and the American homes as of March and April, 1953. They were estimated at 13.9 days supply at the current disappearance rate of this type of protein as explained above. On January 1, 1952, these stocks amounted to about 12.5 days and during the 1945–1950 period they averaged about 14 days supply of animal protein. These stocks included: beef; veal; pork; lamb; mutton; offal; cheese; evaporated, condensed, dry, whole and nonfat dry milk; shell, frozen, and dry eggs; chickens and turkeys; and fresh and frozen fish. It did not include fresh fluid milk which is this nation's largest single source of animal protein, and constituted 33.4 per cent of the supply in 1950. Fluid milk was omitted because the storage-holding capacities of this most valuable protein food are negligible and could be practically wiped out in less than 72 hours should the supply be cut off. This survey does not include canned fish, rabbits, and minor sources of animal food protein.

Population Pressures in the United States

Perhaps it is now becoming clear to the reader that, with the availability of good quality sea foods, our nation is bound to develop an increasing interest in sea-food consumption. This means that, with the proper development of our marine resources, a substantial factor in supplying our national nutrition with high-quality proteins could easily be the sea foods which can be harvested by mariners and processed, packaged, and distributed by processors. While the foregoing facts, concerning the importance of protein foods of proper quality and the prospect of their consumption being increased, are not positive assurances in themselves, the steady increase in population does definitely indicate that our over-all food consumption is bound to go up. It is not generally appreciated that the steady increase in our population exerts great pressure upon our national food production. Perhaps, the following facts will serve to indicate that this is no idle conjecture.

By 1975, the United States must boost agricultural production by the equivalent of 115,000,000 acres merely to feed and clothe the predicted increased population if our present standards of living are to be maintained. Present indications are that we may be able to get an additional 30,000,000 acres from irrigation and drainage projects, flood control, and land-cleaning operations. The conversion of another 15,000,000 acres, from the production of food for draught animals to crops for human consumption as mechanization of agriculture is further advanced, will still leave a 70,000,000 acre deficit. We must then adopt one of two alternatives: (1) reduce our exports and import food; or (2) increase our own food production. The problem of feeding five people in 1975, for every four we are now feeding, is going to pose many problems, not only for American agriculture and fisheries but for the food-processing industries as well. We will not be permitted to forget that our population is increasing faster than is food production – the present ratio being of the order of 15 for present population growth to 9 for current food production increases. Also, we shall come to realize – if we do not already do so – that for about 15 years American agriculture has already faced an "all-out" production demand to meet a continuing and expanding need. It is therefore apparent that our present challenge will have to be met largely by higher yields, improved production and processing practices, as well as by expanded researches of industrial and agricultural chemists and extended practical applications by agricultural extension workers and food technologists.

It would be folly to assume we shall meet this challenge solely on the premise that necessity is the mother of invention. We mortals have no control over the weather. Even our rain makers have not been a howling success.

Nutritional Science and Its Teachings

We have now pointed to certain facts which augur well for any food industry concerned with the production and distribution of products that are rich in high-quality proteins. All known sea foods are of such nutritional quality. Without going into detail, it is apparent that, within the span of a half century, the science of nutrition has presented a constantly changing picture. According to the trends in research, as well as the appeals to the imagination, first one type of emphasis and then another has dominated the prevailing thinking. As a consequence, we have witnessed: (1) an era in which the true significance of the calorie has been realized; (2) a period in which it was ascertained that starvation does not shorten illness or lessen debility; (3) the passing of an era in which "intestinal auto-intoxication" – presumed to be due to a high-protein diet – was considered the cause of almost every ill to which human flesh is heir; (4) the emergence and flowering of the glamourous vitamins and their more prosaic mineral supplements, and finally, (5) the recognition and true appreciation of the value of protein in nutrition.

Perhaps, the most significant fact of all nutritional science is the realization that it is complete systems

(*Continued on page 423*)

Investing in the Future

A Brief Review of the Growth of Research Activities in the United States for the Past Decade

By PAUL COHEN

ORGANIZED research, which may with justice be called the generative organ of the industrial state, is continuing the rapid growth which has characterized it for the past few decades. Not only are this country's expenditures on research growing in dollar volume, they also appear to be taking a larger percentage of the total national income.

An outstanding example is medical research, which in the 10 years between 1941 and 1951, saw a tenfold increase in money allotments. (For research in general, the increase during this same period was fourfold.) In 1940, about 0.024 per cent of the national income went for studies of disease and related problems. In 1950, this country spent three times as much proportionally, that is, not quite one tenth of a cent out of every dollar, or 0.074 per cent on medical research. In this same decade, which witnessed large fund-raising campaigns aimed at combating some of the major causes of death, the federal government rose from a very minor to the major source of funds for such work. Out of the $181,000,000 spent on medical research in 1951, the federal government gave $76,000,000; industry gave $60,000,000; and other sources, including the foundations, contributed $45,000,000.

Compared to the costs of industrial and military research, these sums are trivial. The total amount spent on scientific and engineering research in this country in 1952 is estimated by the Research and Development Board at about three and three-quarter billion dollars. A third of this sum was spent directly by the government or by the colleges and universities (which are in part financed by the government). The remainder of this amount went to support private or industrial laboratories.

An interesting aspect of this growth is the rise of the federal government as a patron of research, although it should be emphasized that this is far more strikingly an increase in absolute magnitude than in the percentage of the total research burden supported by the government. In the period 1936–1937, when the total outlay on research in this country was about $270,000,000 per year, the federal government spent about $120,000,000 per year (of which $50,000,000 were emergency funds), industry spent about $100,000,000, and the contribution of the universities and colleges was about $50,000,000.

In 1952 when the total research outlay was estimated at more than 3.7 billion dollars, the government spent about 2.2 billion dollars. From the immediate prewar period to the present, government expenditures have grown from somewhat more than 40 per cent to about 60 per cent of the total. Most government-sponsored research today is military research, or is at least motivated by military considerations, for the great bulk of government research funds comes either from the Department of Defense or the Atomic Energy Commission.

The Research and Development Board has recently completed a survey dealing with some of the aspects of spending the more than two billion dollars (2.5 billion in 1952) made available annually to industrial laboratories. The survey covered nearly 2,000 companies which together spent about 85 per cent of the funds available for industrial research. Of the 96,000 research engineers and scientists (as contrasted with production engineers or supporting workers such as draftsmen or technicians) employed by these 2,000 companies, two out of three were with companies with 5,000 or more employees. There are 34 companies in this country having research staffs of 500 or more professional employees. Some 18 companies report 1,000 or more research engineers and scientists on their staffs. Half the engineers and scientists in industry now work in groups of more than 500. Undoubtedly, this is a significant factor in the development of engineering unions, and in other shifts from traditional relationships between employer and professional employee which have become evident in the postwar years.

As compared to the small companies, the larger organizations characteristically hire more supporting workers per research engineer or scientist, that is, proportionally more laboratory assistants, machinists, draftsmen, administrative and clerical personnel. On the other hand, there is more tendency for the small companies to subcontract supporting functions. Thus their engineers may assemble the basic information and specifications, lay out the broad outlines of the design, and then have the detailed drawing work and machining of the prototype equipment done elsewhere. On the basis of actual employees, the average support ratio, that is, the number of support workers per research worker, is about 1.5; it varies, however, from 0.9 for companies with less than 500 employees to 1.6 for those having 5,000 or more employees.

Government funds are channeled into a relatively few industries. These are aircraft, electrical machinery, instruments, and (the omnipresent catchall term) nonmanufacturing, which refers primarily to consulting firms and nonprofit research agencies. In

(*Concluded on page 426*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Elected

Voting for officers of the Alumni Association, alumni term members on the M.I.T. Corporation, members of the National Nominating Committee, and class representatives on the Alumni Council, the Institute's alumni body has elected those listed below to administer the affairs of the Association beginning with the fiscal year, July 1, 1954. April 25 was the closing date for the ballot to be received in the Alumni Office.

To the office of president will come Hugh S. Ferguson, '23, for a one-year term. Mr. Ferguson is president of the Dewey and Almy Chemical Company of Cambridge. Gilbert M. Roddy, '31, will serve as vice-president for two years, and on the Executive Committee will be Donald W. Kitchin, '19, and A. Robert Tonon, '22 – also for a period of two years. Mr. Roddy is vice-president of the Boston Manufacturers Mutual Fire Insurance Company and of the Mutual Boiler and Machinery Insurance Company, Boston, while Messrs. Kitchin and Tonon are with the Cambridge firms of Simplex Wire and Cable Company and Peter Gray Corporation, respectively.

The three Alumni elected as alumni term members on the Institute's Corporation, to serve for five years, are: Ray P. Dinsmore, '14, Vice-president, Goodyear Tire and Rubber Company, Akron, Ohio; William J. Sherry, '21, Oil Producer, Tulsa, Okla.; and Horatio L. Bond, '23, Chief Engineer, National Fire Protection Association, Boston.

Named for a term of three years on the National Nominating Committee are: David J. Sullivan, '24, for District 3; William S. Brackett, '23, for District 6; and Morgan A. Collins, Jr., '27, for District 7.

Classes whose numerals end in zero or five elected the following, for five-year periods, to serve as class representatives on the Alumni Council: George A. Packard, '90; Andrew D. Fuller, '95; Elbert G. Allen, '00; Robert W. McLean, '05; Herbert S. Cleverdon, '10; Azel W. Mack, '15; Edwin D. Ryer, '20; F. Leroy Foster, '25; Morell Marean, '30; John D. Hossfeld, '35; John L. Danforth, '40; Thomas A. Hewson, 6–45; and John T. Weaver, '50.

Class Reunions

Listed below is the latest available information on class get-togethers and reunions which are to be held in conjunction with Alumni Day on Monday, June 14, and on other dates:

1894 June 12. Meeting in Room 7–106, M.I.T., 10:00 A.M. Samuel C. Prescott, Secretary, Room 16–317, M.I.T., Cambridge.

1899 June 11–13. Burton House, M.I.T., Cambridge. Burt R. Rickards, reunion chairman, 381 State Street, Albany 10, N.Y.

1900 June 15–17. The Pines, Cotuit, Mass. Elbert G. Allen, Secretary, 11 Richfield Road, West Newton 65, Mass.

1904 June 11–13. *50th reunion* at Oyster Harbors Club, Osterville, Mass. Carle R. Hayward, reunion chairman, Room 35–304, M.I.T., Cambridge.

1909 June 11–13. Chatham Bars Inn, Chatham, Mass. Francis M. Loud, reunion chairman, 351 Commercial Street, Weymouth 88, Mass.

1912 June 11–13. Snow Inn, Harwich Port, Mass. Frederick J. Shepard, Jr., Secretary, 31 Chestnut Street, Boston.

1914 June 18–20. Sheldon House, Pine Orchard, Conn. Charles P. Fiske, reunion chairman, 1775 Broadway, New York 19, N.Y.

1915 June 14. Class family cocktail party, Algonquin Club, 217 Commonwealth Avenue, Boston, from 5:00–7:00 P.M. Azel W. Mack, Secretary, 40 St. Paul Street, Brookline 46, Mass.

1916 June 11–13. The Treadway Inn (formerly Coonamessett), North Falmouth, Mass. Ralph A. Fletcher, Secretary, Box 71, West Chelmsford, Mass.

1919 June 11–13. Wentworth by the Sea, Portsmouth, N.H. Wilfred O. Langille, reunion chairman, Diehl Manufacturing Company, Finderne, Somerville, N.J.

1924 June 11–13. Sheldon House, Pine Orchard, Conn. George W. Knight, reunion chairman, 36 Arden Road, Watertown, Mass.

1929 June 11–13. *25th reunion* at Baker House, M.I.T., Cambridge. Walter H. Gale, reunion chairman, Room 3–207, M.I.T., Cambridge.

1934 June 11–13. Wentworth by the Sea, Portsmouth, N.H. Carl H. Wilson, reunion chairman, 79 Damon Avenue, Melrose 76, Mass.

1939 June 11–13. Snow Inn, Harwich Port, Mass. Oswald Stewart, 2d, reunion chairman, 36 Pleasant Street, Marblehead, Mass.

1944–2 June 11–13. Hotel Curtis, Lenox, Mass.

1944–10 Henry C. Bourne, Jr., reunion chairman for 1944–2, Room 10–119, M.I.T., Cambridge. F. Scott Carpenter, Jr., reunion chairman for 1944–10, 39 Middle Street, Hingham, Mass.

1949 June 12–13. Chatham Crest, Chatham, Mass. Archie H. Harris, 3d, reunion chairman, Arthur D. Little, Inc., 30 Memorial Drive, Cambridge.

For further information please consult your class secretary or reunion chairman to make arrangements for attending Alumni Day events and class reunions in June.

M.I.T. Photos

G. de Santillana | M. S. Livingston | R. C. Lord | W. M. Murray, '33

Professorial Progress

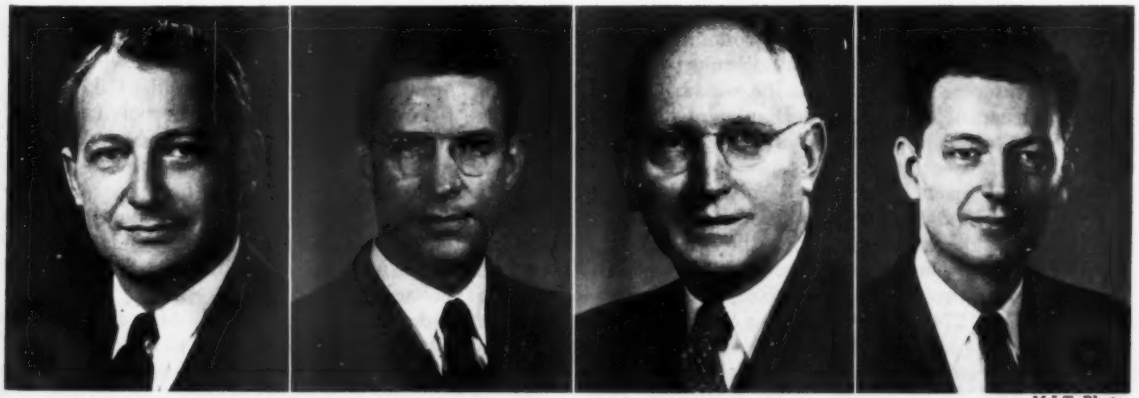
PROMOTIONS on the Faculty of the Institute, which will become effective on July 1, were announced in April. Members of the staff appointed to the rank of full professor are: David F. Waugh, Department of Biology; Glenn C. Williams, '42, Department of Chemical Engineering; Richard C. Lord, Department of Chemistry; Karl L. Wildes, '22, Department of Electrical Engineering; George de Santillana and Walt W. Rostow, both of the Department of Humanities; William M. Murray, '33, Department of Mechanical Engineering; and M. Stanley Livingston, Department of Physics.

Assistant professors promoted to the rank of associate professor are: Holt Ashley, '48, Department of Aeronautical Engineering; Robert M. Solow, Department of Economics and Social Science; Thomas F. Jones, Jr., '40, Samuel J. Mason, '47, and David C. White, all of the Department of Electrical Engineering; Norman C. Dahl, '52, and Kenneth R. Wadleigh, '43, both of the Department of Mechanical Engineering; Martin A. Abkowitz, '40, Department of Naval Architecture and Marine Engineering; and Francis L. Friedman, '49, and Robert W. Williams, '48, both of the Department of Physics.

Promotions to the rank of assistant professor are: Leon Trilling, Department of Aeronautical Engineering; Robert C. Reid, Department of Chemical Engineering; Roy Olton and Jesse H. Proctor, both of the Department of Economics and Social Science; Stephen M. Simpson, Jr., '53, Department of Geology and Geophysics; Lawrence W. Towner, Department of Humanities; Thomas V. Atwater, Jr., Edward H. Bowman, 2–46, and Albert H. Rubenstein, all of the School of Industrial Management; Thomas P. Goodman, 6–45, and Alan H. Stenning, '51, both of the Department of Mechanical Engineering; Richard J. Charles, Department of Metallurgy; and George W. Clark, '52, and Jack W. Rosengren, both of the Department of Physics.

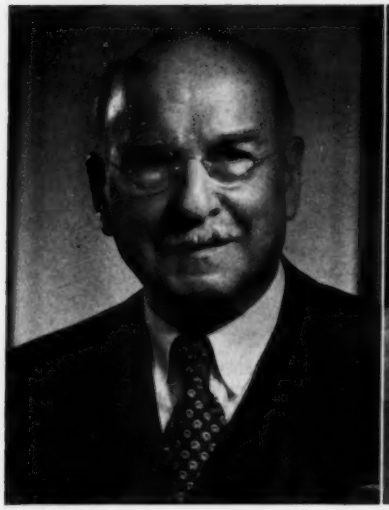
Members of the staff advanced to the rank of instructor include: Edward Arthurs, '51, W. Howard Card, Mahmoud M. Riaz, '50, and Franz E. Steinberg, '51, all of the Department of Electrical Engineering; Thomas F. Ostin and John B. Stewart, both of the School of Industrial Management; Donald G. Aronson, '51, Fred G. Brauer, '53, Noel J. Hicks, John E. Kimber, Jr., '52, and Gustave Solomon, all of the Department of Mathematics; and Wilfred L. Freyberger, '47, Department of Metallurgy.

New appointments include: Robert F. Lambert, Visiting Assistant Professor, Department of Electrical Engineering; Gordon MacDonald, Assistant Professor, Department of Geology and Geophysics; Joseph D. Everingham, Assistant Professor, Department of Humanities; Robert L. Hamman, '49, instructor in the School of Industrial Management.



M.I.T. Photos

W. W. Rostow | D. F. Waugh | K. L. Wildes, '22 | G. C. Williams, '42



Karsh, Ottawa

Pierre S. du Pont, '90

Franklin Grant

William S. Newell, '99

Henry E. Worcester, '97

Three life members of the Institute's Corporation whose deaths occurred during the month of April. Their loss will be shared by M.I.T. and the industries with which they were associated.

Corporation Loses Three Life Members

IT is The Review's sad duty to record the loss, by death, of three life members of the Corporation of the Institute during April. After serving on the Corporation for 35 years, Pierre S. du Pont, '90, died in Wilmington, Del., on April 5, as recorded in the May, 1954, issue of The Review. Four days later, Henry E. Worcester, '97, for many years a member of the Alumni Council and of the Advisory Council on Athletics, died in Orleans, Mass. Death took William S. Newell, '99, one of the nation's leading shipbuilders, in Bath, Maine, on April 18.

Mr. Worcester, who lived in Winchester, was born in Tewksbury, Mass., in 1875. After attending M.I.T. with the Class of 1897, he entered the sugar refining business in New York City. His return to Boston in 1907 as superintendent of the Revere Sugar Refinery was followed by a term from 1920–1946 as vice-president of the Revere Sugar Refining Company. Mr. Worcester was also vice-president of the United Fruit Company from 1929–1946.

A term member of the M.I.T. Corporation from 1931–1936, Mr. Worcester was for many years a member of the Institute's Alumni Council and the Advisory Council on Athletics. In addition to his activities as director of many firms, he was a member of the American Society of Mechanical Engineers, Engineers Club of Boston, Boston Chamber of Commerce, and many others.

Mr. Newell was a life member of the M.I.T. Corporation from 1943–1952 when he became an emeritus member. Founder and chairman of the Board of the Bath Iron Works Corporation, Mr. Newell also established two wartime yards, producing a total of 74 destroyers and 274 freighters during World War II.

The 76-year-old industrialist was born in Albany, N.Y., and received the degree of bachelor of science at M.I.T., where he served as an instructor from 1900–1902. Mr. Newell joined the Bath Iron Works as a draftsman and in 12 years attained the post of engineering works manager. Later he spent two years in a Camden, N.J., yard as general manager before returning to Bath, where he leased the old plant, organized a new corporation, and revived the town's shipbuilding industry with the construction of private yachts. During the depression Mr. Newell kept the yards functioning by a few contracts for fishing trawlers and Coast Guard patrol boats, but at the outbreak of World War II, his shipyards, machinery, and skilled workmen rapidly converted to the production of highly lauded fighting ships. Mr. Newell introduced the sunken-basin construction method to the commercial shipbuilding industry.

Appointed by President Truman to the Atomic Energy Commission, Mr. Newell had also been a member of the American Bureau of Shipping, U.S. Naval Institute, American Society of Naval Engineers, North East Coast Institute of Engineers and Shipbuilders, and American Newcomen Society; a past president of the Society of Naval Architects and Marine Engineers, life member of the society's counterpart in Great Britain, former director of the National Association of Manufacturers, and for many years a director of the National Council of Shipbuilders. Awards for Mr. Newell's work in the field of shipbuilding include two presidential citations and the title of Chevalier in the French Legion of Honor. An alumni term member of the M.I.T. Corporation from 1936–1941, life member from 1943–1952, and emeritus member since 1952, he served as president and director of several firms in Maine and was awarded honorary degrees by Bowdoin and Colby colleges, the University of Maine, and Stevens Institute of Technology.

As recorded on page 358 of the May issue of The Review, Mr. Du Pont was chairman of the Board of E. I. du Pont de Nemours and Company, Inc., a former president of General Motors Corporation, and for 35 years a member of the M.I.T. Corporation.

To Retire

Two members of the Faculty will retire this summer after long service at the Institute. They are John B. Babcock, 3d, '10, Professor of Railway Engineering in the Department of Civil and Sanitary Engineering, and Gordon B. Wilkes, '11, Professor of Heat Engineering in the Department of Mechanical Engineering. Professor Babcock will remain at M.I.T. after July 1 as a lecturer in the Department of Civil and Sanitary Engineering. Both men are popular with the students and have devoted their professional lives to teaching.

M.I.T Photo

John B. Babcock, 3d, '10 . . .

a native of Boston, where he was born in 1889, received the degree of bachelor of science at M.I.T. in 1910. After five years' experience as a railway, highway, and construction engineer, he returned to the Institute as instructor in the Civil Engineering Department. In 1919 he was promoted to assistant professor of railway engineering; in 1925, to associate professor of railway and highway engineering; and, in 1928, to the rank of full professor of railway engineering.

In addition to his teaching activities, Professor Babcock has been a consultant on railway, highway, and airport engineering; and during World War II he served as Railroad Evacuation Officer, Evacuation Division, Massachusetts Committee on Public Safety. Awarded a special prize in 1936 by the Boston Society of Civil Engineers for his presidential address on the society and its founder members, Professor Babcock is also a member of the American Society of Civil Engineers, American Railway Engineering Association, American Society for Engineering Education, and American Road Builders' Association. He is one of the joint authors of a section on Railway, Highway, and Airport Engineering in the *Civil Engineering Handbook.*

M.I.T Photo

Gordon B. Wilkes, '11 . . .

born in Buffalo, N.Y., in 1889, received the degree of bachelor of science at M.I.T. in 1911. He joined the staff of the Department of Physics as an assistant in heat measurements and a year later was promoted to instructor. In 1918 Professor Wilkes was named assistant professor of industrial physics; in 1924, associate professor; and in 1930, full professor. In 1934 he transferred to the Department of Mechanical Engineering, as professor of heat engineering.

The author of a book entitled *Heat Insulation,* Professor Wilkes has written numerous articles on engineering subjects. In the temperature control chamber of the Department of Physics at M.I.T., in 1928, Professor Wilkes conducted tests on insect pests, in co-operation with the United States Bureau of Entomology. In 1942, he directed studies at the Institute, on heat capacity of insulating materials. His extensive research activities included a World War II project for the National Defense Research Council. A fellow of the American Ceramic Society, Professor Wilkes holds membership in the American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers, American Association for the Advancement of Science, and Phi Beta Epsilon.

Undergraduate Endowment

Receipt of a gift of $25,000 for undergraduate scholarship endowment at the Institute has been announced by Dean Thomas P. Pitré, Director of Student Aid at M.I.T. The new scholarship fund has been established by George M. Bunker, President of the Glenn L. Martin Company (Baltimore, Md.) and a graduate of the Institute in the Class of 1931, and a group of his associates. It will provide for a $1,000 scholarship over a four-year period.

In announcing the grant, Dean Pitré said: "We are especially grateful to receive grants for undergraduate scholarship endowment because the Institute urgently needs to increase its capital funds in this area. In common with many colleges and universities, scholarship applications at the Institute have continued to show a sharp upward trend.

"Last year's applications were 50 per cent above those of the year before, and this year's applications are two and a half times what they were four years ago."

The first award under the new grant will be made to a member of next year's freshman class at M.I.T. All awards will be restricted to residents of Maryland and the District of Columbia.

Atomic Wastes Sterilize Food

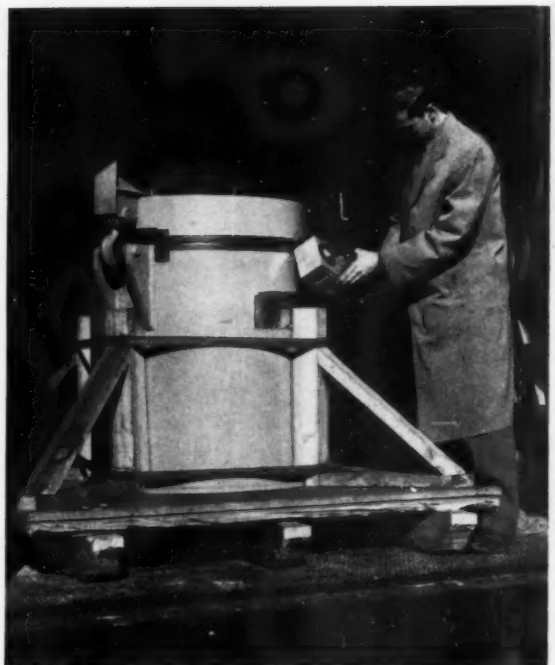
STERILIZATION of food products may soon be an important commercial peacetime use of atomic energy. For the first time, waste products from atomic bomb manufacture are now to be used for experimental irradiation of foods in the laboratories of the Department of Food Technology at M.I.T.

The Argonne National Laboratory, operated by the University of Chicago in Lemont, Ill., has made shipment to M.I.T. of the first of a new type of experimental radiation source which uses nuclear reactor waste products. At M.I.T. this source is to be used in connection with equipment which will for the first time make possible irradiating food in commercial-sized containers.

This, says Professor Bernard E. Proctor, '23, Head of the M.I.T. Department of Food Technology, brings commercial sterilization of food by radioactivity an important step nearer: the radioactive fission products to be used at M.I.T. are a waste product, presumably inexpensive, and they will be used under conditions which for the first time approximate those needed in commercial food production.

Professor Proctor will be assisted by Samuel A. Goldblith, '40, Assistant Professor of Food Technology, in the research program which is under the sponsorship of the Atomic Energy Commission through its Division of Reactor Development. It is a continuation of work under way since 1950 in which radioactive cobalt has been used as a source of nuclear energy.

Stephen Lawroski, Director, Chemical Engineering Division, Argonne National Laboratory, said that the new source which uses the waste products of a nuclear reactor is regarded as a significant step forward in nuclear engineering and in developing peacetime uses of atomic energy.



M.I.T. Photo

Edward Karaian, a member of the Institute's radiological safety group, checks the new radiation source utilizing nuclear reactor waste products on its arrival at M.I.T.

Intercollegiate Rowing

THE cardinal and gray will be represented by three heavyweight crews – varsity, junior varsity, and freshman – in the 52d Annual Regatta of the Intercollegiate Rowing Association to be held on Saturday, June 19, on Onondaga Lake, Syracuse, N.Y.

The Technology crews will compete with oarsmen from Boston University, University of California, Columbia University, Cornell University, Navy, University of Pennsylvania, Princeton University, Rutgers University, Leland Stanford Junior University, Syracuse University, University of Washington, and University of Wisconsin.

The Freshman race will run for two miles and is scheduled to begin at 3:45 P.M., Eastern Daylight Time. The Junior Varsity and Varsity races will cover a distance of three miles each.

Tickets may be purchased through William H. Combs, '54, M.I.T. Crew Manager, 487 Commonwealth Avenue, Boston, or from James Decker, Athletic Department, Syracuse University, Syracuse, N.Y.

As this issue of The Review goes to press, M.I.T. crew members are anticipating the date of Saturday, May 15, when they will compete in the heavyweight sprint championships of the Eastern Association of Rowing Colleges. This event, sponsored by the Washington Rowing Association, will be held on the Potomac River at Hains Point, Washington, D.C.

Acting Head of Course II

PROFESSOR JAMES HOLT, Executive Officer of the Department of Mechanical Engineering since 1946, has been named acting head of his Department pending the appointment of a permanent head, Professor C. Richard Soderberg, '20, Dean of the School of Engineering, announced in April.

Professor Holt was graduated from Harvard University and M.I.T. in 1918, being awarded the degree of bachelor of science simultaneously from each institution. He joined the M.I.T. staff as an assistant in 1919, becoming an instructor in 1920, assistant professor in 1927, associate professor in 1935, and full professor in 1947.

The Council Meets

IN the unavoidable absence of Horatio L. Bond, '23, President of the Alumni Association, the 303d meeting of the Alumni Council was called to order on April 26, by Dwight C. Arnold, '27, Vice-president. As usual, the dinner meeting was held at the M.I.T. Faculty Club in the Sloan Building, and 107 members and guests attended.

Resolutions for two late members of the Council were read: Raymond Stevens, '17, presented the resolutions on Frederick Bernard, '17, and John B. Ilsley,

(*Continued on page 412*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Some years ago it became evident to us that there was a need to make modern information about methods of welding copper and its alloys more widely available. Many industrial companies preferred to use these metals because of such qualities as corrosion resistance, long life, and workability, but were deterred by welding problems. In response to this need, Revere established a Welding Section in its Research and Development Department, to approach the subject from both a theoretical and a practical standpoint. Detailed laboratory studies, reduced to practicality, have enabled the Welding Section to make valuable contributions to industry. Here are a few examples out of many.

• A customer had a contract to make steel pressure vessels, which had to have a copper gasket surface on steel tube sheets. The original design called for machining a groove in the steel, inserting a copper bar, and welding it in place. Then another machining operation would be required to level the surface. Revere suggested that perhaps the first machining operation would be unnecessary if the copper gasket could be applied by welding. The laboratory made a few but important modifications in the inert-gas shielded-arc method, and by developing the correct procedures saved the customer both time and money.

• Another customer was making oil coolers. The heads are threaded, and were being sealed by silver brazing. To remove the heads for cleaning, it was necessary to chip out the braze. We recommended welding as cheaper, just as satisfactory, and also said the weld metal could be more quickly removed when the time came to clean the cooler. Revere was permitted to demonstrate the method, which proved entirely successful. The customer gratefully reported that he was saving between $300 and $400 on each oil cooler.

• Here is a quotation from a recent letter. "Your welding people were in our plant this past week and certainly went beyond what we expected in giving us technical advice. While I say went beyond expectations, what I'm getting at is that they certainly showed the proper spirit of cooperation to any company which is a potential customer or even a customer, as we are. They assisted us very greatly in a couple of problems that we had here at the plant, and I certainly felt it was well worth writing and telling you."

Our many contacts with industry prove to us that suppliers of materials of all kinds possess a great deal of helpful knowledge about the specification, application and fabrication of their products. Such information can be had easily. Just take your suppliers into your confidence, and pursue with them the subject of possible processes and economies.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

Executive Offices: 230 Park Avenue, New York 17, N. Y.

SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

Digital Computer Techniques

Applied to the design, development and application of

Electronic Business Systems
Military Radar Fire Control Systems
Aircraft Control & Navigation Systems

Areas include

LOGICAL DESIGN
COMPONENT DEVELOPMENT
PROGRAMMING
MAGNETIC RECORDING
CIRCUIT DESIGN
INPUT & OUTPUT DEVICES
SYSTEMS ANALYSIS
BUSINESS APPLICATIONS ANALYSIS

The successful application of Hughes airborne digital computers to high speed aircraft fire control problems has opened up an entire new area for these digital computer techniques.

Similar equipment is now under development in the Advanced Electronics Laboratory to apply such digital computer systems to modern business information handling.

Hughes *developments in these fields are creating new positions in the Advanced Electronics Laboratory. Exceptional men in the following spheres of endeavor are invited to apply:*

ENGINEERS AND PHYSICISTS Computer activities embrace systems planning and analysis, design and development, system engineering and component development. Experience in these areas, as well as in application of electronic digital computers, is desirable but not essential. Analytically inclined men with backgrounds in systems work are required for this phase.

COMPUTER APPLICATIONS SPECIALISTS Experience in the application of electronic digital computers to business problems is desirable, but not essential. Specifically, men are required who can bring ingenuity and a fresh approach to a formulation of fundamental requirements of business data handling and accounting problems.

Hughes
Scientific and Engineering Staff

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.

THE INSTITUTE GAZETTE

(*Continued from page 410*)

'97, presented resolutions on Henry E. Worcester, '97 – both of which were accepted by a silent rising vote.

As secretary of the Alumni Association, Donald P. Severance, '38, reported that 39 Alumni, whose undergraduate attendance at M.I.T. had been interrupted by World War II, had requested changes in class affiliation. Also reported was the fact that between March 4 and March 26, eight representatives of the Council had visited affiliated clubs in Haifa, Israel, and nine clubs in the United States as far as Knoxville, Houston, and Minneapolis. It was also announced that, at its meeting in the afternoon, the Executive Committee had approved recognition of the M.I.T. Club of Taiwan (Formosa) which had its first meeting at Taipei on March 24, 1954.

Also announced was nomination, by the Executive Committee, of Theodore T. Miller, '22, for a five-year term on the Alumni Fund Board, succeeding George Warren Smith, '26, whose term expires on June 30, 1954; and decision to publish, in 1955, a new edition of the Alumni Register.

As chairman of the Committee on Alumni Day, Mr. Miller announced final plans for this annual reunion, as already recorded on page 355 of the May issue of The Review.

As Director of the Alumni Fund, Henry B. Kane, '24, reported that 9,085 Alumni had contributed $201,500 to the Alumni Fund, as compared with 8,835 Alumni who had contributed $185,500 at the corresponding time a year ago.

By vote of the Alumni Council, action was taken to amend Article VII, Section 1 of the bylaws to read as follows:

"The annual dues, including subscription to *The Technology Review*, shall be four dollars ($4.00) for all types of members of the Association, other than Honorary or Life Members.

"Any member who in any year has made a contribution to the Alumni Fund of $4.00 or more shall thereby have paid his dues to the Alumni Association for that year."

With the conclusion of these items of business, the meeting was turned over to two guest speakers: Professor John M. Buchanan, Head of the Division of Biochemistry, and Professor Lawrence B. Anderson, '30, Head of the Department of Architecture.

Professor Buchanan spoke briefly of the role of the biochemist in modern science, and mentioned some of the work being done in that Division at M.I.T. With the aid of slides, he illustrated how new tools and techniques of atomic physics and electronics enable the biochemist to do effective work in the medical field. An outline of the work of the Division of Biochemistry was given by Professor Buchanan in the December, 1953, issue of The Review (page 87).

Professor Anderson spoke on the proposed long-range development of the Technology campus west of Massachusetts Avenue, including plans for lower-

(*Continued on page 414*)

COMING IN JUNE!

The record of the Institute's early struggles and triumphs

WHEN M.I.T. WAS "BOSTON TECH"

by Dr. Samuel Cate Prescott, M.I.T. '94

When M.I.T. Was "Boston Tech" records the history of M.I.T. from its beginning — a memorandum written by William Barton Rogers on March 13, 1846, entitled "A Plan for a Polytechnic School in Boston" — to the transfer of the Institute to its home on the Charles in Cambridge in 1916. Told in terms of men who built the Institute, this volume is history in the richest sense. . . . President Killian in a Foreword says of it:

"This book, happily, is more than formal history. It is a personal report, an essay in interpretation and remembrance which is important both for what it tells about M.I.T.'s first half-century and for what it tells about what Dean Prescott finds important and interesting in that half-century.

"Dean Prescott has been associated with the Institute for nearly two thirds of a century. He has known all of its presidents save Rogers, the founder. He has known the Institute from the vantage points of student, teacher, department head, dean, alumnus, and parent. He has had a formative influence on its policy-making and he has been an articulate protagonist of the Institute's program and policies. It is important that a man with this long and various experience at the Institute should write interpretively of its history.

"He views M.I.T.'s formative years not only with an expert's understanding but out of a deep sense of loyalty and devotion. This book is a testament of faith in an institution, an earnest of the author's abiding belief in the staff, students, and alumni he has known. Those who have had the privilege of knowing Dean Prescott and working with him will understand why this is true and will cherish this book as another example of his generosity of spirit and his deep commitment to his Alma Mater."

All royalties from *When M.I.T. Was "Boston Tech"* have been assigned by Dr. Prescott to the Alumni Fund.

---

xviii + 350 pages
with 14 pages
of illustration

$6.00
per copy

THE TECHNOLOGY PRESS Room 14N229, Mass. Inst. of Tech.
Cambridge 39, Massachusetts

My check for $.....is enclosed herewith for.....copies of *When M.I.T. Was "Boston Tech"*. Please mail by prepaid parcel post to:

_____

_____

_____

_____

Grumman

ENGINEERS
needed to
work on new
"Grumman Cat"

Grumman, nearing its 25th Anniversary, needs engineers to work on its new experimental light-weight Naval fighter, plus other jet fighters, anti-sub planes, and amphibians. Grumman has openings for experienced aircraft engineers, and recent engineering graduates.

LAYOUT DESIGNERS AND DRAFTSMEN
Airframe Structures
Equipment Installation
Detail Drafting

FLIGHT TESTING
Planners
Analysts
Computers

HYDRAULICS
Systems Design
Testing

STRUCTURES
Stress Analysis
Static Testing
Applied Loads

Send resumés to Engineering Personnel Dept.
Interviews at Employment office.

GRUMMAN AIRCRAFT
ENGINEERING CORPORATION
BETHPAGE • LONG ISLAND • NEW YORK

(*Continued from page 412*)

ing vehicular traffic on Massachusetts Avenue in the vicinity of the Institute. The new auditorium and chapel (see page 348, May, 1954, issue of The Review) were described, and Professor Anderson's plans showed locations of a proposed skating rink, a student union, additional athletic facilities and playing fields, two tiers of buildings to accommodate fraternities that choose to bring their houses on campus, another single dormitory, and permanent housing for married students and their families.

Nerve Composition

DISCOVERY of a novel biological acid which may provide important clues to understanding the general functioning of nerves was reported in April at a meeting of the American Societies for Experimental Biology in Atlantic City. The new biological substance has been isolated and identified by Bernard A. Koechlin, a research associate in the Department of Biology at the Institute, in recent M.I.T. work with the giant nerve fiber of the squid. It is isethionic acid which is chemically related to certain common detergents and which had not been expected to occur biologically

Dr. Koechlin's discovery solves a 20-year mystery about the chemical composition of invertebrate nerves. For at least two decades biological theory had predicted the existence of an unidentified acid in such nerves. This prediction was based on the fact that the number of known anions, or negatively charged particles, in such nerves was far short of the number expected in theory.

This predicted anion deficit has been accounted for almost exactly by the new substance, together with a small fraction of other acids also identified in the M.I.T. research. These other acids, which contain four carbon atoms (dicarboxylic), are also found in lobster and other invertebrate nerves. They are known to be products of sugar metabolism and consequently may be related to the energy metabolism in the nerve.

Anions are assumed to be involved in the physiological functioning of nerves, whose basic job is to conduct electrical impulses. The nerve impulse in all

(*Continued on page 416*)

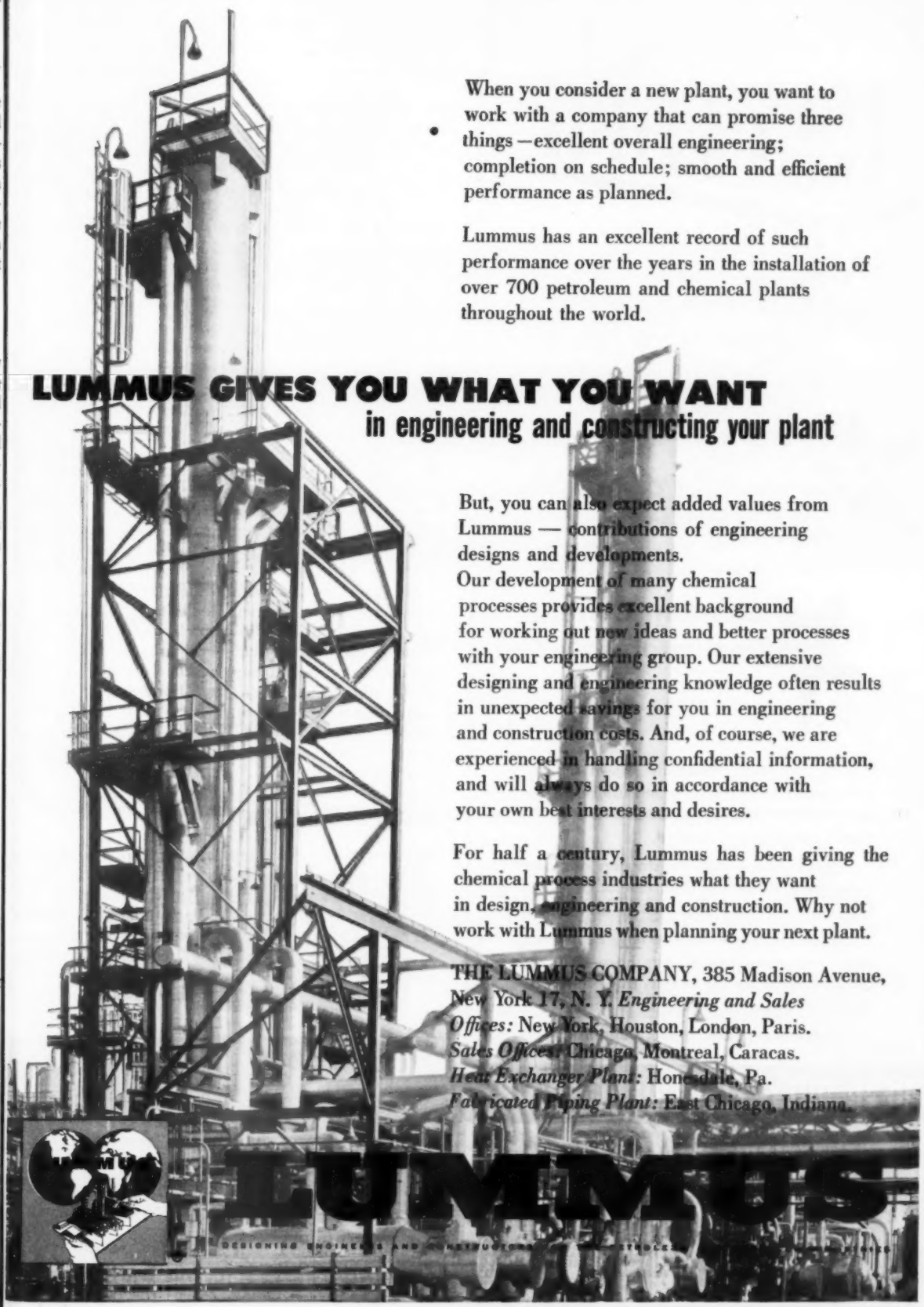
LICENSING ARRANGEMENTS WANTED

We wish to acquire patent rights on electrical components, instruments, or accessories used in the following fields:

RADIO, RADAR, OR TELEVISION. TELEPHONE, TELEGRAPH, TELETYPE, OR SOUND ON FILM. PUBLIC UTILITIES. AIRCRAFT.

Our preference is for items that have limited rather than mass markets. We have a particular interest in switches and relays, also in telephone parts and accessories.

All replies to be held confidential. Please write to Box G Technology Review. SA-3



When you consider a new plant, you want to work with a company that can promise three things—excellent overall engineering; completion on schedule; smooth and efficient performance as planned.

Lummus has an excellent record of such performance over the years in the installation of over 700 petroleum and chemical plants throughout the world.

LUMMUS GIVES YOU WHAT YOU WANT
in engineering and constructing your plant

But, you can also expect added values from Lummus — contributions of engineering designs and developments. Our development of many chemical processes provides excellent background for working out new ideas and better processes with your engineering group. Our extensive designing and engineering knowledge often results in unexpected savings for you in engineering and construction costs. And, of course, we are experienced in handling confidential information, and will always do so in accordance with your own best interests and desires.

For half a century, Lummus has been giving the chemical process industries what they want in design, engineering and construction. Why not work with Lummus when planning your next plant.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y. *Engineering and Sales Offices:* New York, Houston, London, Paris. *Sales Offices:* Chicago, Montreal, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

DESIGNING ENGINEERS AND CONSTRUCTORS

HEVI DUTY

Precision Electric Heat Treat Furnaces
(Laboratory and Industrial)

Dry Type Air Cooled Transformers
(to 1000 KVA)

Constant Current Regulators (Static Type)

Many nationally known laboratories and manufacturing plants use Hevi Duty Electric Heat Treating Furnaces where maximum performance is desired.

Hevi Duty specialty transformers are used extensively in the electrical control of industrial machinery and plant power distribution.

Airport and street lighting have been made safer and maintenance costs have been reduced through the use of Hevi Duty static type Constant Current Regulators.

Write for descriptive bulletins

HEVI DUTY ELECTRIC COMPANY

HEVI DUTY

HEAT TREATING FURNACES • ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS—CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

Harold E. Koch, '22, President
Elton E. Staples, '26, Vice President

(*Continued from page 414*)

animals is an electrical signal sent along a nerve fiber. The key to the electrical energy of the nerve fiber lies in the chemistry of the fiber and the tissue around it, and one of the major aims of nerve research is to try to discover how the chemical processes of nerves are used to produce electrical energy. Dr. Koechlin believes that isethionic acid may be found throughout the animal kingdom.

"There is some evidence," he says, "to support the view that it may occur in other nerves. We feel that a high concentration is somewhat specific throughout marine life and that it may occur in smaller amounts in other nerve tissue. However, the biochemistry of the human nervous system is still largely a mystery and it is impossible to guess what significance further research on this new substance may have. . . ."

Dr. Koechlin explained that work with the squid has been carried on because it is ideally suited to this kind of investigation. Most nerves are small and hard to get at chemically, but pure axoplasm, the inner core of the nerve fiber, can be extracted, from the giant nerve fiber of the squid with comparative ease. It might be said that the squid holds a place in nerve research much like that of the fruit fly in genetics.

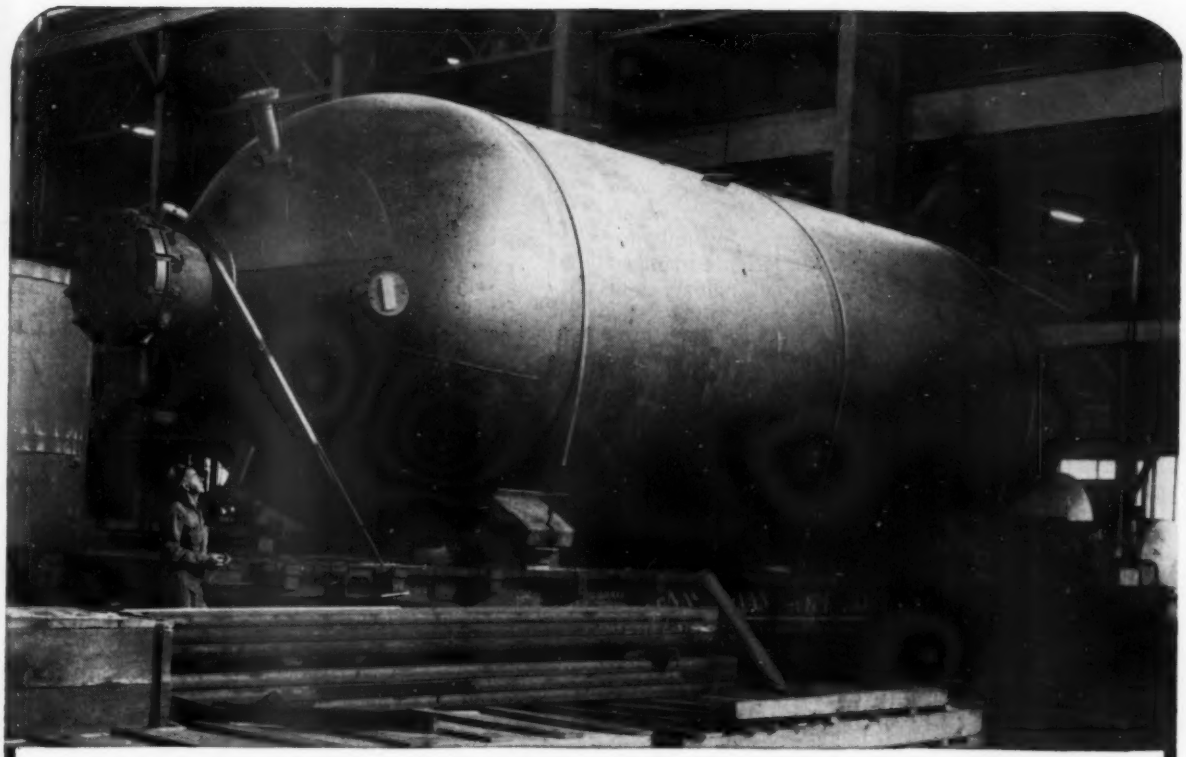
Dr. Koechlin isolated and identified the substance with standard biochemical techniques. The research was supervised by Professor Francis O. Schmitt, Head of the Department of Biology at M.I.T., in a project supported in part by the National Institute of Neurological Diseases and Blindness of the National Institutes of Health (U.S. Public Health Service), by the Office of Naval Research, and by a grant from the Trustees under the wills of Charles A. King and Marjorie King.

Sloan Fellowships

THIRTY young executives, chosen from a wide range of industrial concerns, have been awarded Sloan Fellowships for participation in the Executive Development Program at the Institute, E. P. Brooks, '17, Dean of the School of Industrial Management, announced. This year's Sloan Fellowship group includes four from foreign countries.

(*Concluded on page 418*)

SCULLY SIGNAL COMPANY
Safe Fills No Spills with VENTALARM® WHISTLING TANK FILL SIGNAL
for automotive, home and diesel fuel tanks
F. P. Scully '16
174 Green Street, Melrose 76, Mass.
"JUST FILL 'TIL THE WHISTLE STOPS"



Painstaking care revealed in fabricating HUGE DIGESTERS

GRAVER

PROCESS VESSELS

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

NEW YORK • CHICAGO • PHILADELPHIA • ATLANTA • DETROIT
CLEVELAND • PITTSBURGH • HOUSTON • CATASAUQUA, PA.
SAND SPRINGS, OKLA. • CASPER, WYO. • ODESSA, TEXAS
LOS ANGELES • EDGE MOOR, DEL. • TULSA
SAN FRANCISCO
FONTANA, CALIF.

This gives you an idea of the kind of work Graver does. It is one of nine digesters for a new southern pulp mill, constructed of type 316 extra low carbon stainless clad on a backing of SA212 Gr B firebox quality carbon steel.

However, of particular interest is the extremely careful workmanship exhibited at every stage of manufacture. For example, each solid stainless part of the complex interior was heat-treated and quenched individually... every weld radiographed...every clad surface magna-gauged and the entire vessel, including shell and components, stress relieved in Graver's extra-capacity furnace. No finer digesters have ever been produced.

Painstaking care is typical of all Graver operations. It has, through the years, resulted in complete customer satisfaction.

Graver offers complete fabricating facilities, most modern welding techniques and an unusual ability to work in steel, aluminum and alloys.

THE INSTITUTE GAZETTE

(*Concluded from page 416*)

Under the provisions of the Executive Development Program, the successful candidates are chosen early in their industrial careers when they have a long future service to industry ahead. The program, which continues for one year, provides an opportunity for orientation to the fundamentals underlying management action rather than a review of management policies and techniques.

The fact that the Sloan Fellows carry on their work at a center of technological development, such as M.I.T., provides a special opportunity for the Fellows to view the long-range development of business in the perspective of technological advancement, as well as within the economic and human framework of management problems.

The Sloan Fellows will begin their work at M.I.T. on June 19 under the leadership of Gerald B. Tallman, Associate Professor of Marketing, and Director of the Program.

The Republican Roosevelt

THEODORE ROOSEVELT'S foreign policy anticipated many of our current needs, according to a study just completed by John M. Blum, Associate Professor of History at M.I.T., and associate editor of the recent eight-volume series *The Letters of Theodore Roosevelt.*

In *The Republican Roosevelt,* published by the Harvard University Press, Professor Blum emphasizes that Roosevelt fully realized that the United States could not avoid involvement in the affairs of the world. Roosevelt considered Russia potentially the foremost European power. Although he felt that the decay and despotism of the old Russian empire immobilized her, he predicted that she would be a "serious problem" for later generations.

Roosevelt's concept of power was the keystone of his foreign policy, says Professor Blum. Not only did he accept the oneness of the world, but he insisted that the nation recognize its international obligations and keep in readiness sufficient mobilized resources to honor them.

Roosevelt was never quite sure of Japan, and thought she might possibly "enter into a general career of insolence and aggression." The best preventive, he maintained, was American power, particularly naval power.

"If Roosevelt's policy had faults," Professor Blum concludes, "it also had strengths, and he discerned some permanently useful principles for U.S. policy.

"If the use of force in international society has limitations, it also has legitimate capacities. Without force, the best intentions fail to stop destruction . . .

"Power is a present element in the conduct of world affairs. This being so, the rulers of the nation must be prepared, as Roosevelt was, constantly and unashamed to venture power politics. On this, well done, depends American security and possibly the prevention of another total war."

Add invisible cops to your police force!

Light and lots of it is the very best deterrent there is to crimes of violence. That is why it is so terribly important that residential streets, as well as boulevards and shopping areas, be adequately and dependably lighted.

Dependable lighting has to be more than good looking, scientifically designed lighting fixtures. The power cables are part of it too. Such cables must be able to withstand winter thaws and freeze-up, as well as summer rains. They must also withstand high summer heat and winter cold.

ANHYDREX Series Street Lighting Cables do this and more. They can be buried in the ground or pulled through ducts. Sometimes they are used inside the lighting standard. But regardless of how they are used, they are dependable. They require no lead sheaths or metallic armor.

Want to know more about these versatile street lighting cables that can be used overhead or underground with or without ducts? Write us directly or contact our representative in your area for more detailed information.

Simplex–ANHYDREX
Series Street Lighting Cables

SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Mass.

Doelcam

. . . . offers YOU an opportunity to advance with the modern industrial revolution of this "Computer Age".

AUTOMATIC CONTROL is the equation of the future for which DOELCAM has the solution. Prominent among our personnel who contribute to the young, progressive spirit of this expanding company are 16 M.I.T. alumni.

N. E. Andres '48
N. O. Clark '27
A. F. Coleman '31
J. E. Egbert '44
J. R. Gray '40
T. K. Maples '43
H. D. Marcus '48
K. C. Mathews '46
J. A. Maynard '46
R. E. Quinlan '30
W. A. Rote '42
P. B. Samuelson '32
G. J. Schwartz '42
J. A. Vitka '49
M. P. White '31
J. J. Wilson '29

Instruments for Measurement and Control

Synchros • Gyros • Microsyns • Servo Motors
Servos • Magnetic Amplifiers • Flight Test Equipment

Doelcam CORPORATION

SOLDIERS FIELD ROAD BOSTON 35, MASS.

Write C. F. Taylor, Personnel Mgr.

TRADE MARK TO HALLMARK

Through the years, our trade mark has become a mark of quality that stands for the simplicity, efficiency and dependability of Curtis Universal Joints . . . the Hallmark of the industry.

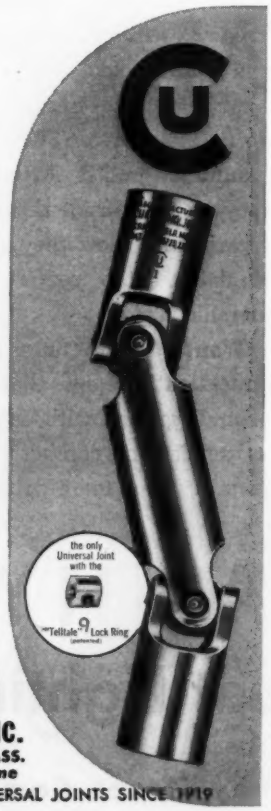
In a wide range of applications, Curtis Joints offer the designer assurance of long life, and trouble-free performance — because they are quality-controlled at each step of manufacture.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock
- Fewer parts, simpler construction
- Complete equipment for government tests

Our catalog torque and load ratings are substantiated by constant tests. You can depend on them.

Not sold through distributors. Write direct for free engineering data and price list.



Trade Mark CURTIS
UNIVERSAL JOINT CO., INC.
8 BIRNIE AVE., SPRINGFIELD, MASS.
As near to you as your telephone
A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

NATURE'S SWEET RESTORER

(*Continued from page 394*)

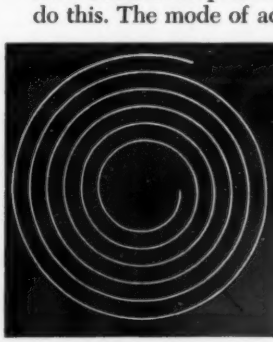
classifications include the sleep-promoting agents as a discrete group, designated the hypnotics.

Let us return for a moment to the central nervous system stimulants, the wakefulness promoters. It is striking that one of these, the methyl purine caffeine (or its close pharmacological and chemical relatives theobromine and theophylline) are used throughout the world, by all peoples, in the form of various stimulating beverages. These include coffee, tea, cocoa, guarana, maté, and carbonated beverages of the cola variety. It is especially remarkable that use of caffeine or caffeine-like substances for stimulation has existed since olden times, when it was independently discovered in various parts of the world by widely separated primitive peoples having no cultural interchange. Tea and coffee, for example, were known to ancient peoples on the Asiatic continent. Kola nuts have long been used by West African natives. Guarana has been drunk by Argentine natives, and maté by Brazilian Indians since before the era of recorded history.

Caffeine, in pure form, is also a basic pharmaceutical stimulant. It is used in standard preparations, in prescriptions, and in proprietary "awakeners." Another classical drug for central nervous system stimulation is strychnine. Benzedrine (also known as amphetamine) is a stimulant that is a relative newcomer to the pharmaceutical scene.

The hypnotics — the sleep-promoting drugs — are more numerous and more diverse than the stimulants. The classical hypnotics include chloral hydrate, veronal, various bromides, and opium derivatives (alkaloids), such as morphine or codeine. A newer class of hypnotics are the numerous derivatives of the barbituric acids, designated as the barbiturates. These include phenobarbital, pentobarbital, amytal, and others known by common or trademarked names. A wide variety of barbiturates are used because they have differing speeds of effectiveness and duration of action. The sleeping pills, concerning which one has, in the past, read newspaper accounts of baleful effects such as dependency, inadvertent overdosage and even intentional overdosage for suicide, have usually been barbiturates. By now the distribution of these potent hypnotics is controlled by means of effective legal regulations.

The hypnotics, paradoxically, do not actually promote natural sleep. Indeed no drug is known that can do this. The mode of action such a drug would need



"Precision-Gauged"
HAIRSPRINGS
Manufacturer of all types of hairsprings, with more than 20 years experience making Beryllium Copper Hairsprings for critical instrument applications.

PRECISION PRODUCTS CO., Waltham, Mass.

to have is equally unknown because, as already pointed out, the basic mechanisms of sleep are not thoroughly understood. Hypnotics act by merely depressing excitability of that part of the brain known as the cerebral cortex; thus they pave the way for the supervention of natural sleep. Therefore hypnotics are ineffective unless other conditions favor sleep.

May pharmaceutical aids to sleep or wakefulness be employed with impunity? Innocuousness of the caffeine-containing stimulating drinks, in moderate amounts, has been established through centuries of use by human beings. They may be used freely to promote wakefulness, and conversely can be avoided when sleep is sought. The other pharmacological aids to sleep or wakefulness one does well to shun, except in emergencies. Even then they should be used only under close medical supervision.

The understanding this article has sought to provide, of the human body temperature cycle and its relationship to sleep, may be fruitfully exploited by those having problems of sleep or wakefulness. The practical course of action indicated is, manifestly, to establish and maintain, so far as possible, precise regularity in hours of going to bed and arising.

DISCOVERY AND INVENTION

(*Continued from page 400*)

As just one example, consider the case of a talented young man from the New York City suburbs. By age 15 he had designed and built an operating liquid fuel rocket engine – alone – an amazing feat which won him First Prize in the regional Science Fair. This 11th-grade high school student should go far in either engineering or science; he has the combination of ability and strong motivation which results in achievement. But he has already decided otherwise: he intends to study medicine rather than engineering, since he could "earn a better living" as a doctor. (See Table 6.) It is worth noting that the prestige and salary value of medicine in the United States have paid dividends in medical discoveries.

In conclusion, the exponential growth of science and technology in the Eighteenth and Nineteenth Centuries has reached a plateau. One authority suggests that further development of technology is likely to come from advances in the sciences. Hence a study of the present state of science can provide a glimpse of the future of technology. The striking feature of

(*Concluded on page 422*)

J. C. CORRIGAN CO., INC.
Conveyers
ENGINEERS · MANUFACTURERS · ERECTORS
•
Coal Handling Systems
Material Handling and Processing Equipment
Portable Conveyers
•
Distributors for
Jeffrey Manufacturing Co.
41 Norwood Street, Boston 22, Mass.
Tel. GEneva 6-0800

If You Need Additional Manufacturing Capacity

CALL IN

LIQUID's

CONTRACT MANUFACTURING DIVISION

◆ Capacity and manpower available on Machine Shop, Sheet Metal and Woodworking facilities for industrial or defense contracts.

Write for illustrated booklet "Special Contract Department" which lists and describes facilities.

Liquid *Contract Manufacturing Division*

THE LIQUID CARBONIC CORPORATION
3100 South Kedzie Ave. • Chicago 23, Illinois
Manufacturers of Brewing and Bottling Machinery, Soda Fountains, Gas Welding Equipment, CO_2 Gas, Dry Ice, Oxygen and Medical Gases

SAVINGS FLOW FROM SPEED-LAY PIPE SYSTEM

EVERYTHING FOR A COMPLETE PORTABLE PIPE SYSTEM

FACTORY PACKAGED
PIPE-COUPLINGS—FITTINGS
VALVES—ACCESSORIES
LIGHTWEIGHT, LABOR SAVING

immediate installation

by one unskilled man. 2½ to 30 o. d. black or galvanized. Ready to lay—without delay.

Complete inventory of all Industrial Pipe, Valves, Fittings, and Flanges.

S. G. ALBERT '29

ap **DELIVERED READY FOR INSTALLATION**

SPECIALISTS IN PREFABRICATED PIPING

ALBERT
PIPE SUPPLY CO., INC.
Berry at North 13th St.
Brooklyn 11, N. Y.
Phone EVergreen 7-8100

SEND COUPON NOW!
ALBERT PIPE SUPPLY CO., INC.
Berry at N. 13th St., Brooklyn 11, N. Y.
Please send free booklet describing your Speed-Lay System and services:
NAME .....
FIRM NAME .....
ADDRESS .....
CITY ..... STATE .....

MELPAR
A COMPLETE FACILITY . . . .
has unusual advantages to offer qualified engineers

RESEARCH • DEVELOPMENT • DESIGN • PRODUCTION

- RADAR AND COUNTERMEASURES
- RADAR BEACONS
- SONAR AND SOUND ANALYSIS
- MICROWAVE COMMUNICATIONS
- FIRE CONTROL EQUIPMENT
- DIRECTION FINDING EQUIPMENT
- FLIGHT SIMULATORS AND TRAINING AIDS
- TELEMETERING AND DATA REDUCTION
- SUBMINIATURIZATION TECHNIQUES

Please send inquiries for additional information to

DEPT. T.P.101
MELPAR, INC.
452 SWANN AVENUE
ALEXANDRIA, VIRGINIA

MELPAR INC.
452 SWANN AVENUE • ALEXANDRIA, VIRGINIA

THE RESEARCH LABORATORY OF
WESTINGHOUSE AIR BRAKE COMPANY

DISCOVERY AND INVENTION

(*Concluded from page 421*)

contemporary science, particularly in the United States, is the emphasis upon applied science at the expense of fundamental research.

A comparison of recent discoveries, inventions, and Nobel prize winners in science indicates that the United States had a lower productivity per capita in pure science than western European countries, even before the recent conversion to applied science. (See Fig. 10.)

Is the present concentration upon applied science justified? When the history of the Twentieth Century has been written, it is to be hoped that the United States will have realized the great destiny appropriate to its vast endowment.

References

1. Anderson, H. Dewey, and Davidson, Percy E., *Occupational Trends in the United States*, page 496 (Stanford: Stanford University Press, 1940); *Statistical Abstract of the United States*, page 128 (U. S. Department of Commerce, 1952).
2. *Story of the American Patent System*, pages 8-12 (U. S. Department of Commerce, 1953).
3. Stafford, Alfred B., "Is the Rate of Invention Decreasing?" *American Journal of Sociology*, **LVII**:539, No. 6 (May, 1952).
4. "Seventy-Five Years of Innovation," *Scientific American*, **CXXIII**:323-325, No. 14 (1930).
5. Sorokin, Pitirim A., *Social and Cultural Dynamics*, page 169 (New York: American Book Company, 1937).
6. Darmstaedter, Ludwig, *Handbuch zur Geschichte der Naturwissenschaften und der Technik* (Berlin, 1909).
7. Trytten, M. H., "The Human Resources of the U. S.: Scientists," *Scientific American*, **185**:71, No. 3 (September, 1951).
8. Steelman, John R., "Science and Public Policy," President's Scientific Research Board, 1947.
9. Report of the American Council on Education, March, 1953.
10. Thorner, I., "Ascetic Protestantism and the Development of Science and Technology," *American Journal of Sociology*, **LVIII**:25 (July, 1952).
11. *World Almanac*, pages 43, 593-594 (New York *World-Telegram*, 1953).
12. *Whitaker's Almanack*, page 485 (London, 1932).
13. *Statistical Abstract of the U. S.*, page 110 (1936).
14. Trytten, M. H., "The New Science Foundation," *Scientific American*, **183**:11-15, No. 1.
15. *Statistical Yearbook of the United Nations* (New York, 1952).
16. Roe, Anne, *The Making of a Scientist* (New York: Dodd Mead and Company, 1953).
17. Aiken, W. M., *The Story of the Eight-Year Study*, page 5 (New York: Harper and Brothers, 1942).
18. *Statistical Abstract of the United States*, page 128 (1952).
19. Riesman, David, *The Lonely Crowd* (New Haven: Yale University Press, 1950).
20. Goodrich, Knapp, Boehm, "The Origins of United States Scientists," *Scientific American*, **185**:15, No. 1 (July, 1951); *Science*, **113**:543 (1951).
21. Prentice, D. B., "College Antecedents of Successful Engineers," *Mechanical Engineering*, **71**:397, No. 5 (May, 1949).
22. *Statistical Abstract of the United States*, page 4 (1952).

DOWN TO THE SEA

(*Continued from page 404*)

of essential nutritional elements that contribute to good health rather than merely those of specific vital factors. Furthermore, studies in nutrition have also led to a generalization that foods of high-quality protein are usually accompaniel by adequate supplies of vitamins and minerals, and other essential nutrients.

Technological Advances in the Sea Food Industry

From the foregoing, it should now be apparent that fish and other sea foods admirably qualify as a source of highly nutritious foods. From a competitive point of view fish have always been a relatively cheaper source of high-quality food protein than most other foods of animal origin, with the sole exception of milk. Furthermore, their harvest (in the expenditure of necessary man-hours) has always been of a relatively higher productivity than that of any other food staples. However, in many respects, the incidental labor problems have been much more complex.

It has been reliably established that fresh-caught, whole fish, promptly deep-frozen, can be brought to shore, thawed, and processed on conventional processing equipment, to yield a product which is in every way equal to that produced from freshly caught fish. Nevertheless, many economic questions must be answered before such processing can be made completely satisfactory. The most important of these is whether the full benefits of modern technology in food processing can be realized without a substantial increase in price to offset the cost of installing and operating refrigeration equipment aboard ship. The improvement in quality which such practice provides might measurably increase the acceptability of much of the fish and shellfish products presently competing with other frozen animal foods. Unfortunately, the fishing industry has been less quality conscious than other branches of the food industry – and most of the trouble lies in the procurement end. Modern filleting machines provide a striking contrast between the old, inefficient, wasteful, unsanitary practices, and those of present-day processing after the fish are brought to shore. However, inefficient and ineffective handling between the catching of fish and their unloading cannot avoid the consequent loss of quality during the interim. There is nothing any food-processing equipment can do that will upgrade any food product – and sea foods generally deteriorate much more rapidly than most other flesh foods.

In addition to advances in fish preservation and food processing, innovations originating in electronics, biology, chemistry, and other technical aspects are contributing to great changes in the fishing industry. Such electronic devices as echo sounders are coming into wider use for navigation and also for the accurate measurement of depth and density of schools of fish. Electrical fishing lines and the assembly of cod and herring in front of trawl net openings by properly applied electrical currents are among other

(*Continued on page 424*)

COOL LIGHTWEIGHT NEW SUMMER CLOTHING MADE IN OUR OWN DISTINCTIVE STYLES

This season's outstanding selection includes suits of washable Orlon† and nylon that require no pressing, Dacron† blended with linen or other fibers, and traditional silk or cottons...colorful, casual new sportwear...good-looking furnishings...all reflecting our quality and good taste.

Suits, from $26.50 · *Odd Jackets, from* $16

†Du Pont's fiber

111 BROADWAY, NEW YORK 6, N. Y.
46 NEWBURY, COR. BERKELEY, BOSTON 16, MASS.
74 EAST MADISON STREET, CHICAGO 2, ILL.
727 WEST SEVENTH ST., LOS ANGELES 14, CALIF.
165 POST STREET, SAN FRANCISCO 8, CALIF.

ESTABLISHED 1818
Brooks Brothers
CLOTHING
Men's Furnishings, Hats & Shoes
346 MADISON AVENUE, COR. 44TH ST., NEW YORK 17, N.Y.
BOSTON · CHICAGO · LOS ANGELES · SAN FRANCISCO

DOWN TO THE SEA

(*Continued from page 423*)

types of electronic fishing equipment. The development of specially treated synthetic fibers for fish nets has resulted in materially reducing the weights of trawl nets as well as their water resistance, thereby increasing fish-catching yields. Also the use of the proper size nets provides essential conservation measures on fish culture.

The impact of science* is truly "converting the fisheries from primitive operations to those of modern industry." There are many advances to be made before capital, management, labor, and even government begin to catch up with those that have already been contributed by technology. The unreasonableness of labor (resulting in exorbitant insurance premiums and inadequate financial returns to invested capital), the stubborn resistance of management to necessary changes, the timidity of capital, and the almost callous indifference of government have all proven deterring factors that have prevented the fishing industry from attaining its proper stature among the food industries of the nation. However, with the growing realization that our country must husband its high-quality food protein resources in face of the mounting pressure of population, there is every reason to believe that a substantial future awaits those who will meet the challenge with which the fishing industry is now confronted. Such an industry can supply our nation with immense food supplies of the highest nutritional quality; in addition, it can also supply us with new raw materials for both our chemical and pharmaceutical industries. And, inasmuch as such an industry now certainly appears to be one concerned with the production of foods of both animal and vegetable origin, it will truly be a sea food, and not merely a fishing, industry.

In passing, it should not be overlooked that the use of unicellular algae, such as Chlorella,† is presently being studied and seriously considered as a food supplement. Already plankton is being harvested, by new techniques, from zones of high concentration at the edge of the Gulf Stream, for the capital required for harvesting operations is less than that required for growing algae. And the production of algae by industrial methods may eventually prove feasible; the Japanese are already attempting to grow algae on a semicommercial scale.

Dried powders of Chlorella cells give a taste and flavor similar to those of powdered green tea and powdered dry "aonori" – the latter being a seaweed commonly used as a seasoning in Japanese cookery. It has been found that the algal powder can be added to various kinds of food, both Occidental and Oriental, to give them an agreeable taste and appearance, while at the same time enhancing their nutritional value by increasing their protein, fat, and vitamin contents. In

(*Concluded on page 426*)

* Daniel P. Norman, "The Impact of Science in the Fishing Industry," *Monthly Review*, Federal Reserve Bank of Boston, December, 1953, and February, 1954.

† Publication 600, Carnegie Institution of Washington, Washington, D. C. (1953).

A. J. WOLFE CO.

Electrical Construction

63 ENDICOTT STREET BOSTON 13, MASS.

G. M. Wolfe
M. I. T. '40

E. H. Wolfe
Tufts '49

William H. Coburn & Co.
INVESTMENT COUNSEL
68 Devonshire Street
Boston

BDC 1865 • BDC 1865 • BDC 1865 •

SYSKA & HENNESSY, INC.
Engineers

DESIGN • CONSULTATION • REPORTS
POWER PLANT • WASTE DISPOSAL • WATER SYSTEMS
New York City

HOLMES & NARVER, INC.
ENGINEERS • CONSTRUCTORS
828 SOUTH FIGUEROA STREET
LOS ANGELES 17
TRINITY 8201

JAMES T. HOLMES
M.I.T. '14

D. LEE NARVER
STANFORD '14

CHAUNCY HALL SCHOOL
Founded 1828. The School that specializes in the preparation of students for the Massachusetts Institute of Technology.
Ray D. Farnsworth, *Principal* 533 Boylston Street, *Boston, Mass.*

LEONARD CONSTRUCTION COMPANY
Engineers and Contractors
SINCE 1905
IN THE AMERICAS AND FAR EAST
37 South Wabash Ave.
Chicago

N. A. LOUGEE & COMPANY
ENGINEERS AND CONSULTANTS
Reports—Appraisals—Depreciation Studies
Rate Cases—Business and Economic Studies
120 BROADWAY NEW YORK 5, N.Y.
N. A. LOUGEE '11 L. A. MATTHEWS '13
J. W. McDONALD, Jr. '20 B. F. THOMAS, Jr. '13
E. S. WEST '40

DOWN TO THE SEA

(*Concluded from page 424*)

fact, it has been reported‡ that the addition of algal powder has resulted in palatable bread, noodles, ice cream, and soups fortified with it. Also, an acceptable soy sauce has been prepared from Chlorella.

There is truly a boom developing for a sea-food industry composed of those who have the courage and the determination to prepare for it. With all its great potentials, however, if it is to succeed, the sea-food industry must realize that it will need to study its marketing methods as carefully as its production and processing techniques. At least, some of its products will have to be sold to the consuming public by appeals different from those presently in use. But, most of all, the sea-food industry needs a new and refreshing point of view before it can hope to lure the consuming public away from its conventional acceptance of some of the highly competitive products of presently superior quality foods.

In all truth, it most certainly appears that we, as a nation, will find it most advisable to once again go down to the sea in ships – for protein!

INVESTING IN THE FUTURE

(*Concluded from page 405*)

these fields, government funds pay for more than half of research work done, the largest ratio being found in the aircraft industry, where 85 per cent of the research is government sponsored. The other fields of industry, however, pay substantially most of their own way. This is true particularly for the chemical, motor vehicle, petroleum and general machinery (not electrical) fields. In the petroleum field, about 3 per cent of its research is government-paid.

The number of research engineers and scientists reported for the field of motor vehicles and equipment was 1,445; the number engaged on aircraft or parts therefor was 20,235. Overall, industry employs about 1.5 research engineers or scientists per 100 employees, but averages, for specific industries vary far from the norm. In the primary metal industries, the figure is only 0.3, that is about one professional research worker per 300 employees, and it is 0.4 in the automobile field. In the aircraft industry it is 4.3 per 100 employees, and in the case of scientific instruments, other than photographic, the ratio is 3.9 per 100 employees.

‡ *Food Technology*, 8:179-182 (April, 1954).

Taconic Farms, Inc.
Laboratory Animals

ROBERT K. PHELAN '30
GERMANTOWN, NEW YORK

PROFESSIONAL CARDS

JACKSON & MORELAND
Engineers and Consultants

DESIGN AND SUPERVISION OF CONSTRUCTION
REPORTS—EXAMINATIONS—APPRAISALS
MACHINE DESIGN—TECHNICAL PUBLICATIONS

BOSTON NEW YORK

LESSELLS AND ASSOCIATES, INC.
RESEARCH—DEVELOPMENT—TESTING—CONSULTATION
Mechanical Design and Analysis

916 Commonwealth Avenue Boston 15, Mass.
BEacon 2-2380

P. E. Kyle '39 T. A. Hewson '45 C. H. Kano '43
R. F. Brodrick '48 A. A. Kheiralla '47

EADIE, FREUND AND CAMPBELL
CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 36, N. Y.
Mechanical — Electrical — Sanitary
Air Conditioning — Power — Process Layouts
J. K. Campbell, M.I.T. '11

GIVEN BREWER
Consulting Engineer

Electric Strain Gage Analysis • *Stress Analysis*
MARION, MASS. TEL. 103, 110
G. A. Brewer '38

THE KULJIAN CORPORATION
Consultants • Engineers • Constructors
UTILITY • INDUSTRIAL • CHEMICAL
1200 N. Broad St., Phila. 21, Pa.
MEXICO CITY • CARACAS • MADRID • ROME • ATHENS • TOKYO • CALCUTTA •
H. A. Kuljian '19 A. H. Kuljian '48

FABRIC RESEARCH LABORATORIES
Incorporated
Research, Development and Consultation for Textile and Allied Industries

665 Boylston Street Boston, Mass.
W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.
ENGINEERS • CONSULTANTS • CONSTRUCTORS
READING, PA.
Malcolm G. Davis '25, *Vice President* Allen W. Reid '12, E. C. Edgar '35
Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory
New York • Philadelphia • Washington
Rome • Manila • Medellin

FAY, SPOFFORD & THORNDIKE
Engineers

John Ayer, '05 Ralph W. Horne, '10
Bion A. Bowman, '09 William L. Hyland, '22
Carroll A. Farwell, '06 Frank L. Lincoln, U. of Me., '25
Howard J. Williams, '20

AIRPORTS — BRIDGES — TURNPIKES
WATER SUPPLY, DRAINAGE AND SEWERAGE
PORT AND TERMINAL WORKS

BOSTON NEW YORK

CLEVERDON, VARNEY & PIKE
Consulting Engineers

HERBERT S. CLEVERDON '10 WALDO F. PIKE '15
Structural Designs Foundations
Heating Ventilating and Plumbing Designs
Industrial Buildings, Reports, Investigations

120 TREMONT STREET BOSTON 8, MASS.

MAURICE A. REIDY
Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER
Estimates and Appraisals
101 TREMONT STREET BOSTON, MASS.

CHARLES NELSON DEBES AND ASSOCIATES
ENGINEERS AND CONSULTANTS
Plant Layout — Electrical — Mechanical
Structural — Sanitary — Acoustical

ROCKFORD TRUST BLDG. ROCKFORD, ILL.
C. N. DEBES '35

MORAN, PROCTOR, MUESER & RUTLEDGE
CONSULTING ENGINEERS
Foundations for Buildings, Bridges and Dams; Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

WILLIAM H. MUESER '22 PHILIP C. RUTLEDGE '33

CHARLES A. MAGUIRE & ASSOCIATES
ENGINEERS

PROVIDENCE BOSTON

Cohasset 4-1020 Hingham 6-2360

FRANK MASSA
Electro-Acoustic Consultant

373 Atlantic Avenue 5 Fottler Road
Cohasset, Massachusetts Hingham, Massachusetts

HOW TO ADD A PLUS TO YOUR PRODUCTS . . .

Find out about the new carbon blacks and other raw materials now being offered by Cabot for the improvement of your product. Not only does Cabot continue to develop new blacks . . . a range which already constitutes the world's greatest variety . . . but Cabot is introducing to industry some exciting new *white* pigments and other products. In addition, there are pine tar products, plasticizers, clays . . . products you should investigate if your goal is constant improvement. You can't afford to miss the new product facts being uncovered daily in Cabot Laboratories and in various other laboratories throughout the country where Cabot materials are being investigated . . . write today for new product facts from Cabot . . .

( ) **NEW** *thermal carbon blacks for mechanical and extruded rubber goods . . . natural rubber tubes. As the world's only manufacturer of a complete range of channel, furnace and thermal blacks, Cabot offers more than 45 different grades for use in rubber, ink, paint, varnish, lacquer, plastics and paper products.*

( ) **NEW** *white uniform calcium silicate—Wollastonite. As an inert paint extender, it has more desirable properties than other extenders singly or combined. Excellent for dry pressing of wall tile and semi-vitreous ceramic products and as a mineral filler for polyester resins.*

( ) **NEW,** *almost chemically pure silica—Cabosil. An "airborne" silica for increasing the viscosity of polyester resins to a desired working consistency. Also used for rubber, plastics, paints, varnish, printing inks, pharmaceuticals, cosmetics, insecticides, adhesives, floor waxes.*

( ) **NEW,** *almost chemically pure, extremely fine alumina pigment—Alon C. For textiles, rubber, plastics, paints, varnish, printing inks, pharmaceuticals, cosmetics, insecticides, adhesives, floor waxes.*

( ) **NEW** *plasticizers offering improved flexibility permanence—Cabflex ODP and Cabflex ODA and others. Two of a complete range of plasticizers developed for the specific improvement of vinyl plastics products.*

( ) **NEW** *Elftex carbon blacks. Fluffy oil furnace blacks specifically developed to give letterpress inks same quality printed blackness previously obtained only with higher priced channel blacks.*

(✓) *For complete information, check the Cabot products that interest you . . . write*

CABOT **Godfrey L. Cabot, Inc.** 77 FRANKLIN STREET, BOSTON 10, MASSACHUSETTS

Branch Offices or Agents in all Principal Cities of the World

new DRAPER LOW COST SPINDLE-

Anti-Friction

for

- STIMPSON or THOMPSON CLUTCH
- SOLID ACORN
- BAND DRIVE
- TOP DRIVE
- TAPE DRIVE

Outstanding in World Spindle manufacture . . . inexpensive and completely reliable. Note these mill proven features:

- LOW COST
- REDUCED OILING CYCLE
- DECREASED VIBRATION
- INCREASED SPEED WITHOUT INCREASED END BREAKAGE
- ALL STEEL BASE CONSTRUCTION
- RUST-RESISTANT FINISH

Cost savers like these belong in your mill operation. Draper offers you a complete line of filling and warp Anti-Friction spindles for use with wood bobbins.

NEW TOP DRIVE SPINDLE
Large Anti-Friction and Medium Anti-Friction constructions.

LARGE ANTI-FRICTION SPINDLE
With Stimpson Clutch — Can also be furnished with Thompson Clutch and Cap.

DRAPER CORPORATION

"Retaining Leadership through Research"

HOPEDALE, MASS.

ATLANTA, GA.
GREENSBORO, N. C.
SPARTANBURG, S. C.

for Highest Accuracy

IN [illegible]OLTAGE MEASUREMENTS

The GR TYPE 1800-A VACUUM-TUBE VOLTMETER

Just consider the features and specifications for this popular measuring tool . . . unsurpassed in Accuracy, Stability, Ruggedness and Operating Conveniences. Thousands are in use in laboratories, schools and research organizations throughout the world.

★ The Type 1800-A VTVM is suited not only to accurate measurements at audio and radio frequencies, it in addition gives reliable d-c voltage indications.

★ Voltage range — 0.1 to 150 volts, a-c in six ranges and 0.01 to 150 volts, d-c — 0.5 volt range permits accurate low voltage readings — the Type 1800-P2 High-Frequency Multiplier, attached to the probe, extends the a-c voltage range to 1500 volts.

★ Basic accuracy is ±2% of full scale on all six a-c and d-c ranges — chart is supplied with instrument for frequency corrections on a-c measurements as high as 500 Mc.

★ High Stability — one zero control for all ranges — resetting not required when switching from one range to other.

★ Completely-shielded probe contains acorn-type diode rectifier connected to input capacitor — various terminations and fittings may be attached to probe to suit particular application at hand.

★ Illuminated meter scale elminates parrallax in readings — meter is protected from overloads; cannot be burned out.

★ High 25-megohm input impedance — 1050 Mc resonant frequency permits accurate measurements at hundreds of megacycles — on d-c ranges, two input resistances: 10 megohms and open grid.

★ Current and power measurements also can be made with the 50-ohm termination-unit (supplied) attached to the VTVM probe.

★ Low-frequency response is excellent — range is extended to 1500 volts at d-c and audio frequencies with the Type 1800-P3 Low-Frequency Multiplier.

★ Operation is from 105 to 125 or (210 to 250) volts, a-c, 50 to 60 cycles — internal voltage regulator eliminates meter fluctuations.

★ Line connector cord, Type 274 and 874 termination connectors, 50-ohm coaxial terminating resistor, and spare fuses are supplied with instrument.

★ Dimensions are 7⅜ x 7½ x 11⅛ inches — Net Weight, 13¾ lbs.

Type 1800-A Vacuum-Tube Voltmeter . . $395
Type 1800-P2 High Frequency Multiplier . $18
Type 1800-P3 Low-Frequency Multiplier . . $35

GENERAL RADIO Company
275 Massachusetts Avenue, Cambridge 39, Massachusetts, U. S. A.
90 West Street NEW YORK 6 920 S. Michigan Ave. CHICAGO 5 1000 N. Seward St. LOS ANGELES 38

Admittance Meters ☆ Amplifiers ☆ Coaxial Elements ☆ Distortion Meters ☆ Frequency Measuring Apparatus ☆ Frequency Standards ☆ Impedance Bridges ☆ Light Meters Megohmmeters ☆ Modulation Meters ☆ Polariscopes Precision Capacitors ☆ Oscillators ☆ U-H-F Measuring Equipment ☆ Parts & Accessories ☆ Signal Generators Wave Analyzers ☆ Variacs ☆ TV & Broadcast Monitors Pulse Generators ☆ R-L-C Decades ☆ R-L-C Standards ☆ Unit Instruments ☆ Sound & Vibration Meters ☆ Stroboscopes ☆ Null Detectors ☆ Motor Controls ☆ Wave Filters ☆ V-T Voltmeters